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TRANSMISSION OF SURRA AMONG ANIMALS OF THE EQUINE SPECIES [1]

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TWO PLATES

While nearly a half century has elapsed since Griffith Evans(1) discovered that surra was due to a trypanosome, the precise way in which the infection is commonly transmitted from animal to animal is still more or less of a question and the subject of considerable contention. True, it is generally accepted that the disease is conveyed through the agency of biting or blood-sucking insects, and in this connection most investigators consider flies the important agents. However, one has but to peruse the literature to find that practically every biting or blood-sucking pest of horses, cattle, buffaloes, camels, dogs, etc., in surra districts has, at some time, been looked upon with suspicion by one investigator or another in connection with the transmission of surra.

Though it is conceded that flies are the probable important transmitting agents, there is considerable disagreement as to which species can and which cannot convey the infection. Further, it has not been satisfactorily settled whether transmission is purely mechanical or a result of cyclic development of the trypanosome within the body of the fly.

[1] From the United States Army Medical Department Research Board, Bureau of Science, Manila.

In 1901 Rogers,(2) impressed by the finding of Bruce that *Trypanosoma brucei* of nagana was conveyed from one animal to another by the bite of the tsetse fly, conceived the idea that surra among horses in India might be transmitted in a similar manner. Accordingly, he conducted a series of surra transmission experiments, using dogs and rabbits and "horseflies." The flies were caught, allowed to bite an animal whose blood contained large numbers of trypanosomes, and then after varying periods of time allowed to bite normal animals. Rogers stated his results as follows:

> In every case in which the flies had been kept from one to four or more days after biting the infected animals, no disease ensued in the healthy ones. Many such flies were dissected and microscopically examined, but in no case was anything found which might be taken for a development of the trypanosome in the tissues of the insect treated. * * * When, however, flies which had just sucked infected blood were immediately allowed to bite another healthy animal, positive results were obtained after an incubation period corresponding with that of the disease produced when a minimal dose of infected blood is inoculated into an animal of the same species. The result was uncertain if only one or two flies were allowed to bite, and especially if they were allowed to suck as much blood as they wished without being disturbed. If, on the other hand, several flies, which had just sucked an infected animal, were induced to bite a healthy one, and especially if they were disturbed and allowed to bite again several times, infection was always readily produced in both rabbits and dogs.

Rogers failed to indicate the species of fly he worked with, merely referring to it as a "horsefly." His is the first record reporting flies as transmitting agents in surra.

The year following Rogers's report, Curry, of the United States Army Medical Corps,(3) published an article on surra in the Philippines and announced that from observations he was convinced that *Stomoxys calcitrans* was the common vector of the disease. Apparently no experimental transmission work was done to substantiate his belief.

In 1903 Schat,(4) working with surra in Java, reported flies of the genera *Stomoxys* and *Lyperosia* as important disseminating agents of the disease in that country.

Musgrave and Clegg,(5) in 1903, concluded that the disease was conveyed through wounded surfaces, in which biting insects, particularly flies and fleas, served as the principal agencies. *Stomoxys* and *Tabanus* were both considered of importance.

In an article published in 1905 Manders(6) states that surra on the Island of Mauritius is "almost certainly" conveyed by *Stomoxys geniculatus*.

In 1908, Fraser and Symonds,(7) working in the Federated Malay States, reported the mechanical transmission of surra with several species of Tabanidæ. They failed to transmit the disease in similar experiments in which *Stomoxys* and *Hæmatopota* were employed. Experiments for the purpose of demonstrating whether species of *Tabanus* could transmit the disease in any but a mechanical manner were negative.

Leese,(8) in a summary of his work (1909), says in part:

> I consider it well established, therefore, that *Tabanus* is the most dangerous transmitting fly and that *Haematopota* (large species) is also dangerous. I believe too that *Stomoxys* is involved in a considerable degree in the transmission of surra * * *.

As regards *Lyperosia* he states that—

> circumstantial evidence points to their share in mechanical transmission as being very insignificant, if any.

Leese failed to transmit the disease in any but a mechanical way.

In 1911 Gaiger(9) referred to surra being prevalent when Tabanidæ were not found, and stated that species of *Stomoxys* were probably equally capable of transmitting the disease mechanically.

Baldrey,(10) in 1911, conducted experiments with *Tabanus* and *Stomoxys* with a view of determining whether or not a life cycle of the parasite occurred in flies of these genera. While his feeding experiments were negative, he observed, microscopically, what he believed to be evidence of cyclic development in the flies and expressed the opinion that the trypanosome "was either arrested or that the cycle is completed in another way, probably through the egg of the fly or by a second cycle through a mammalian animal." The "stages" in the life cycle observed by Baldrey were probably degenerative forms.

In an editorial appearing in a bulletin(11) of the Sleeping Sickness Bureau in 1911, the following statement is made:

> Even if the mechanical theory of transmission is satisfactory in explaining some epidemics of surra, this does not exclude the possibility that a development occurs in some invertebrate host. Since *Trypanosoma lewisi* has its cycle in the flea, fish trypanosomes their cycle in leeches, various trypanosomes of animals and *Trypanosoma gambiense* their cycle in tsetse-flies, it does seem probable that the same holds good for *Trypanosoma evansi;* but to say this is not to say that direct transmission never occurs.

Laveran and Mesnil(12) in their Trypanosomes et Trypanosomiases state that *Stomoxys* is looked upon as a potent factor in surra transmission.

Leese,(13) in 1912, reiterated his belief in the mechanical transmission of surra and again reported Tabanidæ, *Haematopota*, and *Stomoxys* as transmitting agents. He indicated, however, that he believed Tabanidæ to be the most important.

In 1912 Mitzmain,(14) in a series of well-planned experiments, obtained a single positive result in attempts to transmit surra with laboratory-bred *Stomoxys calcitrans*. The positive result followed in a case where a succession of two hundred and six interrupted bites were inflicted by flies transferred immediately from an infected to a normal animal. Tests for cyclic development of the trypanosome in the fly were negative, some of the flies used being kept as long as ninety-four days.

Mitzmain,(15) in 1913, conducted a series of experiments with laboratory-bred *Tabanus striatus* and in three cases succeeded in transmitting the disease with these flies. In one test a monkey was infected by three flies which had been interrupted after starting their feed on an infected guinea pig. In the other two cases, horses were infected by two and six flies, respectively, which had just previously started to feed on an infected horse. Cyclic transmission experiments with Tabanidæ were all negative. In the latter connection the flies were all laboratory bred and were kept for as long as twenty-six days after an infectious feeding. No developmental forms were recognized microscopically.

In 1914 Mitzmain,(16) in another publication, indicated his failure in surra-transmission experiments with *Aëdes* and *Culex* mosquitoes. He noted that mosquitoes harbor viable trypanosomes for a longer period of time than does any other blood-sucking insect with which he worked. Mitzmain also failed to produce surra in healthy animals through the agency of *Lyperosia exigua* and with blood-sucking gnats (*Culicoides judicaudus*).

Castellani and Chalmers,(17) in the 1919 edition of their Manual of Tropical Medicine, make the statement that *Stomoxys calcitrans* "is suspected of spreading trypanosomes, especially *T. evansi*." They further indicate that the trypanosome appears to develop in various species of *Tabanus* and *Stomoxys*. In addition to flies, they state definitely that fleas can transmit the infection.

Herms,(18) in his Medical and Veterinary Entomology, published in 1923, quotes Mitzmain's results in transmitting surra with *Tabanus striatus* and agrees that *Stomoxys calcitrans* is

of no practical importance as a carrier of the surra trypanosome. Herms states that "the *Stomoxys* fly has been regarded by some authors as an important carrier of this trypanosome. Unfortunately there is little or no conclusive experimental evidence in favor of this theory."

Cross,(19) in 1923, obtained positive results in ten out of fifteen experiments with *Tabanus albimedius* in interrupted feeds. In additional experiments, flies (*T. albimedius*) were fed on surra-infected animals and then, after periods varying from one to four days, were fed on healthy animals with negative results.

Working with ticks (*Ornithodorus crossii*), Cross failed to infect by the interruption process of feeding. However, he reports positive results in two instances out of twenty in which time was allowed for cyclic development of the surra trypanosome within the tick. The interval between feeding the ticks on an infected dog and feeding them on normal animals was one month in one case and seventeen days in the other. In this experiment the blood of the dog on which the ticks were initially fed contained numerous trypanosomes. In another series of experiments, in which the infected dog showed no trypanosomes in the circulating blood, one positive result was obtained by feeding ticks on a white rat one month following the feed on the dog. Cross concludes that ticks are incapable of spreading surra by direct transmission, but indicates that there is probably a cyclical development of the trypanosome within the tick.

In 1924 Yamasaki,(20) in an article entitled "Trypanosoma evansi und die mechanische Übertragung der pathogenen Trypanosomenarten," argues in favor of mechanical infection of vertebrate hosts.

Craig,(21) in his work on protozoa published in 1926, states:

> The exact method of transmission of *Trypanosoma evansi* is still unknown, although many insects have been suspected. In the Philippines a careful study of the transmission of the infection led me to believe that *Stomoxys calcitrans*, the common stable fly, was the transmitting agent. There is little doubt that the trypanosome is transmitted mechanically by various species of *Tabanus* and *Stomoxys*, and Mitzmain, in the Philippines, has obtained successful infections in animals through the bite of *Tabanus striatus*. There is no evidence that the trypanosome passes through a cycle of development in these flies, but the evidence is conclusive that infection may occur directly by their bites provided not too long an interval is allowed between an infected feed and the biting of the uninfected animal.

Hutyra and Marek,(22) in their latest edition of Pathology and Therapeutics of the Diseases of Domestic Animals, in treating of trypanosome diseases state that—

> natural infection in the domestic animals, exclusive of dourine in which it occurs by coitus, usually results from the stings of flies, namely, *Glossinae*, *Tabanidae* and *Stomoxys* species. Transmission is accomplished in such a manner that the flies take up the trypanosomes while sucking blood from infected animals, which then multiply in their intestinal tract, undergo morphological changes in the same, penetrate the salivary glands and from here reach the body of another vertebrate host with the saliva when the fly again sucks blood from such animal. The different species of trypanosomes are not dependent upon certain species of biting flies, but the different species of flies, especially *Glossinae* may become infected with different trypanosomes pathogenic for mammals. A direct, purely mechanical transmission without a change of generation is doubtful according to the results of more recent investigations.

In another section, in treating of surra, Hutyra and Marek state:

> It has not up to date been determined whether flies transmit trypanosomes in a purely mechanical way, or whether the parasites, similar to the trypanosome of nagana pass through a generative stage in the tsetse fly.

Wenyon,(23) in his Protozoology published in 1926, states:

> It will thus be seen that up to the present the only known method of transmission of *Trypanosoma evansi* in nature is a mechanical one, in which various biting insects inoculate healthy animals within a short time of their having fed on infected ones. It would seem very probable, however, that this is not the whole story, and that further research will reveal some form of development in the fly, leading to a permanent infection similar to that which occurs in various species of *Glossina* in Africa.

In going through the literature and in conversations with persons interested in surra one soon becomes aware that possible analogy between the mode of transmission of human trypanosomiasis (sleeping sickness), nagana of lower animals, and surra has been a potent factor and influence in accepting or rejecting reports on surra transmission. In other words, failure definitely to incriminate an intermediate host in which the surra trypanosome undergoes developmental stages previous to its transmission to other animals has, purely as a result of comparison with other trypanosomiases, caused a number of investigators to take a skeptical attitude toward reports which point to direct, mechanical transmission of the disease. Such individuals practically all take the position that, while some cases of surra may be the result of direct mechanical infection, the common mode of infection will sooner or later be found to follow cyclic develop-

ment of the parasite in the body of the vector, as is the case in human trypanosomiasis, nagana, malaria, yellow fever, dengue, etc.

I have no hesitancy in stating that I leaned toward the latter view when the present reported work was initiated. The thought which immediately presented itself was that it was certainly not in accord with usual biological procedure for a protozoan organism as complex as the surra trypanosome to have to depend upon accidental mechanical transmission for its perpetuation. However, the investigations herein recorded have forced a change of attitude in so far as the transmission of surra to animals of the equine species is concerned.

SURRA TRANSMISSION EXPERIMENTS WITH STOMOXYS CALCITRANS

Stomoxys calcitrans is a well-known, common, and widely distributed blood-sucking fly pest, particularly of equine species and, as already indicated, has been held by a number of investigators to be an important factor in the spread of surra.

Several transmission tests were conducted with this fly. The first attempts to convey the disease with *Stomoxys calcitrans* were carried out with wild flies. However, as this species is easily reared under artificial conditions, the use of wild flies was discontinued and those raised in the laboratory were substituted.

The method of breeding the flies consisted in placing a number of females in quart fruit jars containing from 1 to 1.5 inches of guinea-pig fæces. The tops of the jars were covered with gauze. A small amount of water was added to insure sufficient moisture. After several days the flies were found to have laid eggs and died. The jars were then placed in the incubator at 37.5° C. and maintained there until the eggs hatched and the resultant larvæ passed through the pupal stage and emerged as mature flies. This entire process required approximately fifteen days. During the time the jars were in the incubator a few drops of water were added to the manure from time to time to maintain an ample amount of moisture. After the flies emerged they were collected and maintained individually in cotton-stoppered test tubes. Each test tube contained a piece of filter paper to control moisture. The flies used in experiments were transferred to fresh tubes at least every other day; in some instances every day.

In carrying out the transmission tests the flies were applied one at a time to the test animals by removing the cotton plug

of the tube and quickly inverting the tube over the shaved area of the skin of the animal. By keeping the flies in individual tubes they live longer. Further, this method of applying them to the animal permits of an accurate check on the number that bite.

In one experiment thirty flies were fed on a surra-infected white rat each day, commencing the day following infection of the rat and continuing up to the day the rat died (sixth day). These flies were then fed daily on a normal white rat over a period of twenty-seven days, when the last of the flies died. Examination of the blood of the rat every other day over a period of thirty-one days subsequent to the last fly bite failed to demonstrate trypanosomes. The rat was then given an injection of blood containing *Trypanosoma evansi*, to prove its susceptibility. It promptly developed surra and died on the seventh day, its blood at the time of death containing swarms of trypanosomes. This experiment indicates that the surra trypanosome is not transmitted by *Stomoxys calcitrans* following cyclic development of the organism within the fly.

With a view of determining whether or not *Stomoxys calcitrans* could transmit surra mechanically, twenty-two flies of such species were fed back and forth on an infected white rat and on a normal one. The blood of the infected rat was swarming with trypanosomes at the time of the experiment. In this test a fly was permitted to bite the infected rat and to start drawing blood. It was then disturbed by tapping the tube and immediately transferred to the healthy rat and permitted to bite it and start to suck blood. It was then disturbed and placed on the infected animal, allowed to bite and commence taking blood when it was again disturbed and placed on the normal animal. By this procedure the fly would bite each rat two or three times before completing its meal. This practice was followed with all of the twenty-two flies. After the flies had all fed a number of them were crushed on slides and examined microscopically and their stomach contents found to contain large numbers of trypanosomes.

The normal rat was kept for fifty-six days without showing evidence of disease, microscopic examination of the blood at frequent intervals failing to reveal trypanosomes. To prove its susceptibility it was then inoculated with blood containing *Trypanosoma evansi*. It developed surra in four days and died on the eighth day.

In another experiment fifteen flies were fed back and forth on an infected rat and on a normal one, in the manner described above, on each of four consecutive days. The results were negative.

In still another experiment twenty flies were fed back and forth each day on an infected rat and on a normal one, the feedings being continued from the day following infection of the rat until the seventh day, when the infected rat died. The disease was not transmitted to the normal rat, which was kept under observation for over three months. It was then artificially infected and died of surra.

These experiments indicate that *Stomoxys calcitrans* does not commonly transmit surra in a mechanical manner.

SURRA TRANSMISSION EXPERIMENTS WITH LYPEROSIA EXIGUA

Lyperosia exigua (buffalo fly) is very common in the Philippines and, in so far as cattle and carabaos are concerned, is more of a pest than *Stomoxys calcitrans*. It can be found throughout the year and has frequently been considered a factor in surra transmission.

In carrying out transmission experiments with this fly the same procedure as was employed with *Stomoxys calcitrans* was followed. The first experiments were conducted with wild flies but, later, those bred in the laboratory were employed. The flies were kept separate in individual test tubes and applied one at a time on infected and susceptible animals.

In the first experiment thirty-five wild flies were caught and placed in individual test tubes. The following day six were found dead. The remaining twenty-nine were given an opportunity to feed back and forth on an infected white rat and on a normal one. Twenty-six of the flies fed, the remaining three refusing to bite. The next day four of the twenty-nine flies were found dead. The remaining twenty-five were again fed back and forth between the infected and the normal rats. All of the flies bit. The normal rat was observed over a period of one month, frequent blood examinations being made for the detection of the presence of trypanosomes, with negative results. Following artificial inoculation with blood containing *Trypanosoma evansi* the rat promptly developed surra and died.

A second experiment was conducted with *Lyperosia exigua* in which twenty-five laboratory-bred flies were fed back and forth, on each of three consecutive days, on an infected white

rat and a normal one. The normal rat was kept under observation forty-one days, and frequent blood examinations were made. It failed to develop surra, but when inoculated with a small amount of blood containing *Trypanosoma evansi* promptly developed the disease and died as a result thereof.

In a third transmission test twenty-seven laboratory-bred flies were fed, on each of three consecutive days, on an infected white rat and on a normal one. The blood of the normal rat was examined frequently over a period of thirty days with no evidence of infection. This rat was then kept for approximately two months when it was artificially infected with surra and then treated with a trypanocidal chemical prepared by Doctor Loevenhart, of the University of Wisconsin. A cure resulted and the rat survived for over six months when it gave birth to a litter of young and died following complications in connection with parturition. Repeated blood examinations made up to the time of the death of this rat were negative for trypanosomes.

With a view of demonstrating possible cyclic development of the surra trypanosome in *Lyperosia exigua*, thirty laboratory-bred flies were fed on a surra rat from the day following infection up to and including the fourth day subsequent thereto, when the infected rat was found to have a considerable number of trypanosomes in the circulating blood. Following this the flies were fed daily on a normal rat over a period of nine days, when the last of the flies died. The normal rat was subjected to frequent blood examinations over a period of thirty-two days subsequent to the last fly bite. It failed to develop surra and was then inoculated with blood containing *Trypanosoma evansi*, following which it promptly developed the disease and died.

It would have been desirable to keep the flies over a longer period of time in tests for cyclic development, but it was found impossible to maintain them in captivity, even when bred in the laboratory, for more than approximately two weeks.

These tests indicate that *Lyperosia exigua* does not commonly transmit the surra trypanosome mechanically. In so far as transmission following cyclic development of the trypanosome in the fly is concerned, our experiments, as far as they went, were negative.

TABANUS STRIATUS IN SURRA TRANSMISSION

Following the completion of the transmission experiments with *Stomoxys calcitrans* and *Lyperosia exigua*, the large horse-fly *Tabanus striatus* was scheduled for investigation. Work

with this fly would have been started previous to the investigation of *Stomoxys calcitrans* and *Lyperosia exigua*, but at the time the surra-transmission studies were undertaken *Tabanus striatus* was exceedingly hard to find. Mitzmain(24) states that in the vicinity of Manila *Tabanus striatus* is prevalent from October to March. The period of prevalence, however, undoubtedly varies considerably in different years. During 1926, for example, *Tabanus striatus* commenced to make its appearance in and around Manila in appreciable numbers during the latter part of July. By the middle of August great numbers of these flies were in evidence.

In August, 1926, a serious outbreak of surra occurred among the horses and mules at Fort William McKinley, a United States Army post located about 8 kilometers from Manila. This outbreak afforded an excellent opportunity for study of the disease under natural conditions and in connection therewith the rôle of *Tabanus striatus* in the transmission of the disease was well established and further substantiated by experimental evidence.

In connection with the Fort McKinley outbreak, it should be pointed out that the best of conditions existed for an accurate epidemiological study. All animals on the post were under constant, competent veterinary supervision, and complete and definite information was available as to where the different animals had been quartered, contacts they had been subjected to, etc. As the data obtained from the study of the outbreak of surra there afford abundant evidence of the part *Tabanus striatus* played in the spread of the disease, a detailed description of the outbreak follows.

The first case of surra at Fort William McKinley was discovered on August 23, 1926. Three or four weeks previous to the discovery of this case, one of the veterinary officers from the post brought to the Medical Department Research Board, for identification, a species of fly which had started to make its appearance in various places about the post. I identified this fly as *Tabanus striatus* (Plate 1).

The case of surra discovered on August 23 was a mule in the Service Company, 45th Infantry. The previous sick record of this animal showed that it had been in the isolation ward and corral of the Veterinary Hospital from June 27 to August 19, 1926, undergoing treatment for epizoötic lymphangitis. Thus, it had only been back in its own organization (Service Company, 45th Infantry) four days when it was found to have surra. It was evident, therefore, that this animal had become

infected while in the isolation ward and corral of the Veterinary Hospital. This fact immediately led the veterinary officers to make an examination of twenty-five animals then remaining in the isolation ward and corral. As a result of this and subsequent examinations, between August 24 and September 16, 1926, twenty-three cases of surra were found to have developed among these twenty-five animals.

The isolation ward and corral of the Veterinary Hospital are located but a very short distance from Pasig River. *Tabanus striatus* breeds along the shores of this river. Further, carabaos and oxen, a large percentage of which have been found to be carriers of the surra trypanosome, are commonly seen in the river in this locality and frequently pass along the road which parallels the stream. Another important point is that the isolation ward and corral are located at the edge of a small ravine which drains the surrounding area. This ravine contained a growth of bamboo which extended up to the isolation corral and overhung the fence. This bamboo jungle was found to harbor hordes of *Tabanus striatus*, large numbers of which fed on the horses and mules in the corral. A further interesting finding was that, unknown to the veterinary authorities, the military police had constructed a small corral in the midst of this bamboo jungle for the impounding of carabaos found loose on the military reservation. While hidden from view, this impounding corral was not more than 100 to 150 meters from the isolation corral.

The activity of *Tabanus striatus* among the horses in the isolation corral was carefully observed on several occasions. It was noted that, when this species of fly alighted on a horse standing quietly in the corral, it caused the animal great concern and almost invariably gave rise to movements which resulted in the insect flying off to attack a neighboring horse. A number of flies thus disturbed in their feeding were observed to bite two or three horses in the course of a minute or two.

The first case of surra discovered had mingled with one hundred thirty-eight animals in the 45th Infantry corral for four days. However, no cases of surra developed among these contacts. The area of the 45th Infantry is located approximately 1.2 kilometers from the Veterinary Hospital area. At no time were flies of the species *Tabanus striatus* observed in this area, although frequent careful search for them was made. On the other hand, *Stomoxys calcitrans* was present in large numbers.

On August 12, 1926, an animal under treatment for epizoötic lymphangitis was removed from the isolation corral of the Veterinary Hospital and returned to its organization, the 34th Ambulance Company. On August 31, 1926, this animal was examined and found to have surra; its blood was swarming with trypanosomes. From the evidence at hand, it was obvious that this animal had been infected while in the isolation ward and corral of the Veterinary Hospital. After being returned to its own organization, it was in close contact with approximately sixty-one animals for nineteen days. Only one case of surra developed among the contacts. The area occupied by the 34th Ambulance Company is about a quarter of a mile from the Veterinary Hospital area, and it is significant that *Tabanus striatus* was but rarely seen in this area.

On August 12, 1926, three animals which had been under treatment for epizoötic lymphangitis were discharged from the isolation corral of the Veterinary Hospital to the 23d Wagon Company. On August 31, 1926, blood specimens from these three animals were examined by Fort William McKinley veterinary officers and two were found to have surra. Two days later (September 2, 1926) the third animal was found to have the disease. The 23d Wagon Company had approximately two hundred sixty animals which were in contact with the cases sent from the veterinary isolation corral. Between September 2 and September 18, 1926, a total of sixteen cases of surra developed among the contacts. The 23d Wagon Company occupied an area about 410 meters from the veterinary isolation ward and corral, and its area was one of the localities where large numbers of *Tabanus striatus* were constantly found. A heavy bamboo growth, somewhat similar to that adjacent to the veterinary isolation ward and corral, was located in close proximity to the 23d Wagon Company's corral and afforded a favorable resting place for *Tabanus striatus*.

The contact animals of the 34th Ambulance Company and those of the 23d Wagon Company were moved from their respective areas to a rifle range about 1.6 kilometers from the post proper. On the range they were placed in small groups on picket lines, each line being separated from the others by at least 150 feet.

Because of the absence, in the area of the Service Company, 45th Infantry, of *Tabanus striatus*, to which all evidence pointed as the transmitting agent, it was decided not to move the animals of the Service Company unless a case developed among the

contacts. Of course, daily blood examinations were made of these animals as also of all contacts in the other groups. Although, as previously indicated, the original case of surra was discovered in a mule returned from the isolation corral of the Veterinary Hospital to the Service Company, 45th Infantry, no cases developed among the contacts in the latter organization.

The twenty-five animals in the isolation ward and corral of the Veterinary Hospital at the time of the discovery of the initial case were not removed to another location, for several reasons. In the first place, the evidence was definite that the infection had its origin in this group of animals. It appeared obvious, therefore, that a number of the animals in this group were possibly in the incubative stages of the disease. Subsequent developments proved the accuracy of this belief. In view of these circumstances and considering that the group was small, it was decided to allow them to remain where they were rather than run the risk of introducing a number of potential cases of surra in the area selected for the isolation of other contacts.

The bamboo jungles in the region of the isolation ward and corral of the Veterinary Hospital and in the locality of the 23d Wagon Company were cleared and drained by engineer detachments. During the clearing of these areas, large numbers of *Tabanus striatus* were encountered.

In order to remove the menace of carabao carriers, a post order was promptly issued prohibiting carabaos from coming on the military reservation.

After the animals had been moved to the rifle range, it was discovered that a few Tabanidæ were present in this region. However, by segregation of the animals in small groups, daily blood examinations of all animals, and prompt destruction of cases as soon as found, there was no great opportunity for the spread of the disease. As a matter of fact, of the cases discovered among the animals of the 23d Wagon Company after their removal to the range, the time element indicated very definitely that, in all but one or two instances, infection must have occurred before arrival on the range. In the one or two cases which showed up a little later, it is entirely possible that they too were already actually infected when taken to the range. As noted, only one case of the disease developed among the contacts in the 34th Ambulance Company before their removal to the range, and no cases occurred after they were placed on the range.

After the outbreak at Fort McKinley had gotten under way, transmission experiments with laboratory animals were inaugurated, to substantiate the epidemiological findings. On August 31, 1926, eleven flies (*Tabanus striatus*) were caught in the region of the isolation ward and corral of the Veterinary Hospital, where cases of surra were still occurring among the horses and mules remaining of the original group of twenty-five. These flies were promptly taken to the laboratory and immediately given an opportunity to feed on a normal white rat, each fly being applied to the rat separately by means of test tubes. Of the eleven flies five, which had not obtained their fill on the horses, bit the rat and sucked blood. The other six flies were either engorged or were slightly injured when caught and therefore did not bite. Several of the flies which were engorged when caught and which did not bite the rat were killed and their stomach contents examined microscopically. In the stomach contents of one fly numerous trypanosomes, morphologically indistinguishable from *Trypanosoma evansi*, were demonstrated (Plate 2, fig. 1). On September 11, 1926, eleven days following the fly bites, the white rat was found to have trypanosomes in its blood (Plate 2, fig. 2). Four days later the rat died of surra. A guinea pig inoculated with a small amount of blood taken from the rat shortly before it died likewise developed the disease and subsequently died as a result thereof.

Shortly after the Fort McKinley outbreak was over, an additional surra-transmission experiment was conducted with laboratory animals. Eight female flies of the species *Tabanus striatus* were caught on the Fort McKinley reservation and fed back and forth on a guinea pig infected with surra and on three normal white rats. The guinea pig's blood at the time was found to contain a large number of trypanosomes. Two of the three rats developed surra as a result of the fly bites, one on the eleventh day following exposure and the other on the twelfth day. Both rats died of the disease, one on the fourth day following the detection of trypanosomes in the blood and the other on the sixth day. Guinea pigs inoculated with blood from these two rats likewise developed surra from which they eventually died.

With a view of demonstrating that *Trypanosoma evansi* transmits surra only in a mechanical way, after the eight flies above referred to had been fed back and forth on the infected guinea pig and the normal rats, they were given the opportunity on sub-

sequent days to feed on a normal white rat without first biting an infected animal. This was continued up to the eighth day, when the last of the flies died. Only five of the eight flies bit during this period, the other three having died without having bitten again. The rat was observed over a period of several months, and there was no evidence of surra; it was finally inoculated with blood containing *Trypanosoma evansi*, and promptly developed surra and died as a result thereof.

It would have been desirable to conduct further tests with *Tabanus striatus* over a longer period of time to eliminate more definitely the possibility of cyclic development of the trypanosome within the fly. However, it was found impossible to keep wild flies alive for any great length of time, and the rearing of *Tabanus striatus* under laboratory conditions is exceedingly difficult. On the other hand, the evidence obtained on the mechanical transmission of surra by *Tabanus striatus* is quite definite. Further, the evidence obtained by Mitzmain with laboratory-bred *Tabanus striatus* was all against cyclic development of the trypanosome within the fly.

To summarize the situation, the outbreak of surra at Fort William McKinley coincided with the appearance of *Tabanus striatus* at various places on the post. It originated among animals in the isolation ward and corral of the Veterinary Hospital. This ward and corral adjoined an area which harbored hordes of *Tabanus striatus*. These flies had ready access to numerous carabaos, a large percentage of which have been demonstrated to be carriers of *Trypanosoma evansi*. The spread of the disease among animals which were in direct contact with cases from the isolation ward and corral depended upon the presence of *Tabanus striatus*. Experimentally, surra has been readily transmitted to normal white rats by the bites of *Tabanus striatus* when such flies have just previously fed on an infected animal.

The conclusion that the infection is spread in a purely mechanical manner by *Tabanus striatus* is further substantiated by several observations in connection with the Fort McKinley outbreak. With the clearing of the bamboo jungles in the vicinity of the veterinary isolation ward and corral and the 23d Wagon Company area, the flies promptly invaded other nearby localities on the post and were frequently seen attacking animals in the new localities. With an absence of cases of surra among such animals, the fly bites proved harmless. Then the rapid spread

of the disease among the involved groups and its prompt termination when infected animals were promptly removed and destroyed are opposed to transmission after cyclic development of the trypanosome in the fly. With the large number of susceptible animals on the post (approximately 900), a vast number of Tabanidæ, and cases of acute surra to provide the source of infection, surra would have continued to make its appearance wherever these flies migrated had the infection spread as a result of cyclic development of the trypanosome within the fly. As a matter of fact, *Tabanus striatus*, in rather large numbers, could be found about the post for months after the outbreak; but, with no surra cases present and carabaos restricted from the reservation, the fly was not a menace.

SURRA TRANSMISSION EXPERIMENTS WITH MOSQUITOES

Most students of surra transmission have given thought to the possibility of mosquitoes acting as agents in the dissemination of the disease. Practically all reports on work done with mosquitoes have been negative.

The author conducted a series of transmission experiments with laboratory-bred *Aëdes ægypti* and in two instances obtained positive results in interrupted feeding tests. In one such test ten mosquitoes were fed back and forth, one at a time, on an infected white rat and on a normal one. As soon as the mosquito inserted its proboscis and commenced to draw blood, it was interrupted and placed on the normal rat and permitted to bite and draw a little blood. The interruptions were made at very short intervals, some of the mosquitoes biting six or seven times before becoming engorged. The mosquitoes were fed in this manner as often as they would bite during a period of eight days, the period terminating with the death of the infected rat. The normal rat exposed to the bites of the mosquitoes was found to have trypanosomes in its circulating blood sixteen days subsequent to the first bite, and it died six days later. A guinea pig and a dog inoculated with blood from this rat both developed surra and died as a result thereof.

In the second experiment in which positive results were obtained six mosquitoes were employed. They were fed back and forth on an infected rat and on a normal one in the manner above described, every day for six days, when the infected rat died. On the eighteenth day following the initiation of the test the originally normal rat was found to have trypanosomes in its blood. It died of trypanosomiasis eight days later. In the

meantime a guinea pig was inoculated with a small amount of blood from this rat and it promptly developed surra from which it died approximately five weeks later.

A test was conducted with a view of determining whether or not *Aëdes ægypti* could transmit surra following cyclic development of the trypanosome within its body. Twenty mosquitoes of this species were placed, one at a time, on an infected rat daily from the day following the infection of the rat up to and including the sixth day, when it died. These mosquitoes all took blood the first day they were placed on the rat. None would bite on the second day, but on subsequent days they fed irregularly, a number on the third day, a few on the fourth, etc., up to and including the sixth day, when the rat succumbed. These mosquitoes were then fed, as often as they would bite, over a period of thirty-two days on a healthy white rat. The rat failed to develop surra and after being kept in the laboratory eighty-one days was artificially inoculated. It promptly developed the disease and died as a result thereof.

The two positive results obtained in our work point to the possibility of mosquitoes sometimes being responsible for cases of surra among animals. However, while it is probable that mosquitoes are responsible for the transmission of occasional cases of surra, it does not appear likely that they are a common factor in the spread of the disease under natural conditions. This is obvious when it is considered that the mosquito will ordinarily bite an animal, complete its meal, and leave without the animal being aware of it. Under such circumstances frequent interrupted feeding on several animals is not likely to be of common occurrence.

SURRA TRANSMISSION EXPERIMENTS WITH TICKS

Several series of experiments were conducted with ticks for the purpose of determining, if possible, whether or not such insects could transmit surra. The ticks used were *Boophilus australis* and *Dermacentor recticulatus.*

In one experiment thirty young female ticks (*Boophilus australis*) were removed from a "ticky" cow and half of them placed on a surra-infected dog and the other half on a rabbit infected with surra. Those placed on the rabbit would not remain. Those placed on the dog remained and commenced to suck blood. However, three or four of the ticks on the dog were lost as a result of the animal scratching. After being allowed to remain on the infected dog just long enough to insure that they

had partaken of the blood containing trypanosomes, the ticks were carefully removed and placed on a normal dog. Several of the ticks were lost by the second dog, as only seven were found on the animal several days later. The normal dog was kept under observation for approximately six weeks and showed no evidence of surra, although frequent blood examinations were made. It was then artificially inoculated, promptly developed the disease, and died as the result thereof in about one month.

An experiment similar to the above was conducted with ticks of the species *Dermacentor recticulatus* removed from a dog. The results were negative.

Further experiments were conducted with ticks of the two species mentioned which were raised from eggs under laboratory conditions. These tests were all negative.

In addition, eggs from female ticks which had been permitted to suck blood containing *Trypanosoma evansi* were ground in a mortar with a small quantity of sterile physiological saline solution and injected subcutaneously into white rats. The results were negative. Further, "seed ticks" hatched from eggs laid by females which had fed on infectious blood were likewise ground in salt solution and injected into white rats. No infection resulted from such procedure.

RESERVOIRS OF TRYPANOSOMA EVANSI

Frequent mention is made in the literature of carriers of various pathogenic trypanosomes among water buffaloes, cattle, and various wild animals. In the Philippine Islands carabaos and cattle have from time to time been found to harbor *Trypanosoma evansi* without manifesting appreciable evidence of disease. Practically all Filipinos engaged in agricultural pursuits will state that, if horses are allowed to mingle continually with carabaos, sooner or later the former will develop surra. While a definite surra-carrier problem, particularly with carabaos, is thus recognized in the Philippines, a careful survey of the literature fails to give any idea as to what proportion of carabaos and cattle are carriers of the organism in question.

The usual method for the detection of carriers of trypanosomes has been to examine microscopically a drop or two of blood from the suspected animal. Under normal conditions, trypanosomes are very frequently present only in small numbers in the circulating blood of carriers or they may even be entirely absent from it for temporary periods. Thus, the microscopic examination of a drop or two of blood will, in many instances, fail to disclose a real carrier.

Observations have demonstrated that, when the normal resistance of a carrier is lowered, the trypanosomes will often be found in considerable numbers in the circulating blood, rapidly diminishing in number when the animal returns to its usual state of health. This is nicely illustrated by a study of a group of carabaos subjected to rinderpest vaccination by the simultaneous method. Twenty carabaos purchased in different parts of northern Luzon were assembled by the owner at the experiment station of the Philippine Bureau of Agriculture, for immunization against rinderpest. Microscopic examination of the blood of these animals revealed one carrier of trypanosomes. When injected with the rinderpest virus and serum most of these carabaos developed temperature reactions.

Examination of the blood during such reaction revealed four of the lot to be carriers of trypanosomes. With the termination of the reaction the trypanosomes soon became so scarce in the circulation that microscopic examination of a drop or two of blood failed to reveal their presence.

With a view of developing a more accurate means for determining whether or not an animal is a carrier of *Trypanosoma evansi*, the author introduced the use of the complement-fixation test. It was found that blood-serum specimens from carabaos and cattle harboring *Trypanosoma evansi* will give a positive reaction to the complement-fixation test for trypanosomiasis. The positive reactions were then checked, in a representative number of cases, by guinea pig-inoculation tests for the purpose of proving the accuracy of the test and identifying the type of trypanosome.

The antigen employed in the complement-fixation test is similar to that first described by Watson of Canada and later by Reynolds and Schoening(25) of the United States Bureau of Animal Industry. A description of the method of preparing it follows.

Ten or more white rats are inoculated subcutaneously or intramuscularly with blood from a previously infected rat whose blood is found to contain numerous trypanosomes. Rats are employed because trypanosomiasis in such rodents runs a short, acute course, the trypanosomes in the circulation increasing rapidly, so that in four or five days the blood is swarming with them. Death of the rats would ordinarily occur in from five to seven days, but they are not allowed to die. When the blood is found to be swarming with the organisms the rats are bled to death by severance of the carotid arteries and jugular veins

after the animals have been stunned by a blow on the head. The blood is caught in approximately an equal part of 2 per cent sodium citrate in physiological saline solution. After the blood has been collected from all of the rats it is placed in one or more centrifuge tubes and centrifugalized at high speed for forty-five minutes. Examination will show the blood cells packed in the bottom of the tube, and on top of them a thin, white upper stratum consisting largely of trypanosomes. The supernatant fluid is drawn off, care being taken not to draw up any of the layer of trypanosomes. At one time it was the practice to collect carefully the white layer of trypanosomes with a small pipette and discard the rest of the material. It has been found, however, that a good many trypanosomes are contained in the mass of packed cells; so, instead of removing the white layer, distilled water is added to the cell mass in sufficient quantity to lake the red blood cells completely. The mixture is then centrifugalized at high speed for forty-five minutes. It will then be found that the trypanosomes have been "thrown down" in the bottom of the tube together with a little cell débris and possibly a few cells which escaped laking. The supernatant fluid is drawn off, care being taken not to get too close to the trypanosome mass. A little sterile physiological saline solution is added to the tube for the purpose of washing the trypanosomes, and the centrifugalization process is repeated. After this wash fluid is drawn off, one part of 50 per cent glycerine in physiological salt solution is added to one part of packed trypanosomes. This constitutes the stock antigen. If it is placed in a tightly stoppered test tube and maintained at a temperature around the freezing point, or even in a frozen state, it can be kept for a month or more. A satisfactory method is to place the tube of antigen in an ice-salt mixture and keep it in a refrigerator at low temperature, and renew the ice-salt mixture every day.

For use the stock antigen is diluted from 1 : 10 to 1 : 20 with sterile physiological saline solution and then titrated.

To date, in connection with carrier work, the complement-fixation test for trypanosomiasis has been applied to blood specimens from a total of 141 carabaos, 54 cows and bulls, and 228 horses, the latter animals having been in contact with surra cases.

The carabaos represented animals from different parts of Luzon. For example, one lot of carabaos tested was made up of animals purchased at thirteen different points in four prov-

inces of Luzon. These animals were purchased at such points and shipped immediately to the experiment station of the Bureau of Agriculture at Pandacan, for immunization against rinderpest before being shipped south for work in the fields of a large sugar central. They were specially selected and to all outward appearances were fine specimens and in perfect health. Immediately after their arrival at Pandacan blood specimens were procured, which were subjected to the complement-fixation test for trypanosomiasis. Of the twenty animals, blood specimens from thirteen gave positive reactions to the complement-fixation test for trypanosomiasis. Guinea pigs inoculated with 10 cubic centimeters of blood from four of the thirteen reactors, picked at random, demonstrated the presence of trypanosomes. Blood from the guinea pigs was then inoculated into white rats, the latter animals dying of surra in from six to nine days.

It is of interest to note that when these twenty carabaos were given the simultaneous rinderpest vaccination, direct microscopical examination of their blood during the febrile reaction revealed numerous trypanosomes in the blood of four of those with the highest temperatures.

The above-described experience is representative of tests with other groups. Of the 141 carabaos tested to date, 73 gave positive reactions to the complement-fixation test for trypanosomiasis. Of the 54 head of cattle, 12 positive reactions were obtained. No carriers have been found among animals of the equine species. In such animals the disease runs a progressive course terminating in death within a few weeks.

It should be borne in mind that the complement-fixation test for trypanosomiasis will be positive if an animal is harboring or is affected with any type of trypanosome or trypanosome disease. However, in the Philippine Islands the only type of pathogenic trypanosome known to be present is *Trypanosoma evansi*. In one or two instances a cow or bull has been found to be harboring a large, nonpathogenic trypanosome similar to or identical with *Trypanosoma theileri*. This parasite, however, can be readily distinguished morphologically and, further, it cannot be propagated in guinea pigs or rats. For practical purposes a positive complement-fixation test for trypanosomiasis, obtained with blood specimens from carabaos and cattle in the Philippine Islands, can be considered as evidence that the animals from which the specimens were procured are carriers of *Trypanosoma evansi*.

DISCUSSION AND CONCLUSIONS

A survey of the literature on surra reveals that the precise method by which the infection is spread from animal to animal has not been conclusively settled to the satisfaction of all concerned. With the possible exception of Cross's work with ticks, there is no definite evidence whatever indicating the possibility of an insect vector spreading the disease after cyclic development of the parasite within its body. On the other hand, a number of investigators have reported success in the mechanical transmission of the disease by flies. Though it is accepted that flies are the agents commonly disseminating surra, there is considerable disagreement as to which species can and which can not transmit it.

Hesitancy to accept readily the evidence that the mechanical method of transmission is the common mode of dissemination of the disease among animals of the equine species is due to the inclination to draw an analogy between surra and other trypanosomiases and protozoan diseases in which it has been shown that infection does follow cyclic development of the parasite within the body of the insect vector.

As a result of the study herein reported the conclusion is drawn that the common disseminating agent of surra among animals of the equine species, in the Philippine Islands at least, is *Tabanus striatus*, and the mode of transmission purely mechanical.

It is entirely possible and perhaps probable that *Trypanosoma evansi* may be transmitted to a natural host in a manner more in conformity with what is ordinarily expected of a protozoan organism of such type or, in other words, following cyclic development of the parasite in an intermediate host. Thus, if the carabao, ox, or some wild animal is the natural host of *Trypanosoma evansi*, an intermediate agent may be found transmitting the infection after cyclic development of the trypanosome within its body. However, it is obvious that the horse is not the natural host of *Trypanosoma evansi*, as otherwise it would not be likely to suffer serious consequence as a result of the trypanosome's presence within its body. When *Trypanosoma evansi* does "accidentally" gain entrance to the body of an animal of the equine species disease promptly results. Thus, the common spread of surra among horses can be considered as merely incidental to the feeding habits of Tabanidæ, and the direct mechanical mode of transmission as entirely tenable.

Our experiments with *Stomoxys calcitrans* and *Lyperosia exigua* failed to demonstrate that either of these flies is a factor in surra transmission.

Experiments with the ticks *Boophilus australis* and *Dermacentor recticulatus* likewise failed to indicate that these insects were concerned in the dissemination of *Trypanosoma evansi.*

In two instances the surra trypanosome was transmitted to healthy white rats by mosquitoes of the species *Aëdes ægypti.* In these tests the mosquitoes were fed back and forth on infected and on normal rats. It is thus probable that mosquitoes may be responsible for an occasional case of surra. However, as a mosquito will usually bite a horse, complete its meal, and depart without the animal's knowledge, it is not probable that such insects are common factors in the spread of the disease.

In the Philippine Islands carabaos and, to a lesser extent, cattle are common reservoirs of *Trypanosoma evansi.* Under ordinary circumstances such animals usually show no impairment of health whatever as a result of the trypanosome's presence. On the other hand, when the normal resistance of the animal is lowered the surra parasite rapidly increases in number in the circulation and at such time the carrier is particularly dangerous.

Tests of one hundred forty-one carabaos from various parts of Luzon revealed over 50 per cent of the number to be carriers of the surra organism. Similar tests, conducted with fifty-four cows and bulls from several localities in Luzon, demonstrated about 22 per cent to be carriers.

The number and distribution of carriers of *Trypanosoma evansi* are another strong argument against the infection of animals of the equine species by permanently infected insect vectors. If surra were spread in such manner the equine population of the Philippine Islands would have been wiped out long ago.

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ILLUSTRATIONS

PLATE 1

Tabanus striatus, the common transmitting agent of surra among horses in the Philippine Islands.

PLATE 2

FIG. 1. *Trypanosoma evansi*, in stomach contents of *Tabanus striatus* caught on horse at Fort William McKinley.

2. *Trypanosoma evansi*, in blood of rat infected by bites of *Tabanus striatus* caught at Fort William McKinley.

PLATE 1. TABANUS STRIATUS LINNÆUS.

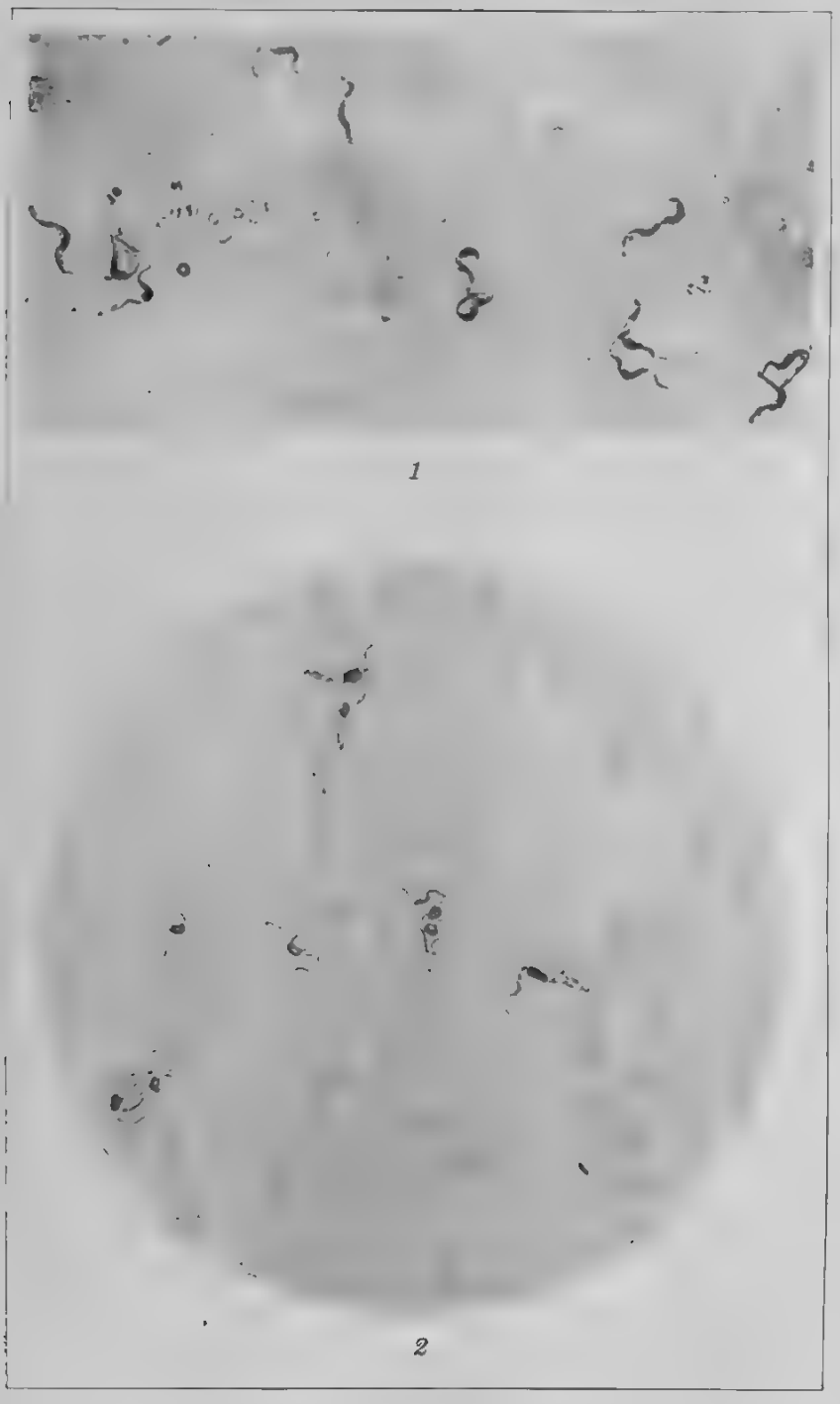

PLATE 2. TRYPANOSOMA EVANSI.

THE NEGROS EARTHQUAKE OF 1925

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TWO PLATES

The present report is the result of observations made from November 26 to December 3, 1925, when the writers were in southeastern Negros, in response to the insistent request of the officials of Oriental Negros Province for information regarding the nature of the violent earth shocks which culminated on May 5, 1925, and the probability of recurrence.

The earthquake that occurred in southeastern Negros on May 5, 1925, will figure in the seismic history of the Philippines as one of the worst, not only for its extent but also on account of the destruction and casualties it caused. On March 1, 1922, just thirty-seven hours after the Cebu earthquake, southeastern Negros was shaken by violent shocks which caused some damage. These shocks did not attract much attention because the public was rather concerned by the Cebu earthquake. Three years later, in January and February, 1925, three series of moderate shocks took place. These were the forerunners of the more-violent earthquake of May 5, 1925, which caused the loss of some twenty human lives as well as considerable damage to property, particularly in Bais, Tanjay, Siaton, and Bayuan (Tolong).

GENERAL GEOLOGY

Southeastern Negros was a volcanic island which, by successive eruptions, was tied to the mainland of Negros by extrusives and ejectamenta. The cluster of volcanic peaks lies to the west of Dumaguete, and attains a maximum elevation in the Cuernos de Negros, or horns of Negros, which are 1,903 meters above sea level. Farther west from Dumaguete, some 20 kilometers from the coast, is Lake Balinsasayao, at an elevation of 976 meters. This lake and a smaller lake separated from it by a

narrow wall occupy the basin of the crater of an old volcano. Both lakes are typical crater lakes, very deep near the center and more or less circular in plan, and their walls of volcanic materials rise precipitously to a great height. The larger lake has a maximum diameter of about 1.5 kilometers and a minimum diameter of about 1 kilometer. It is reported that the larger lake is about 375 meters deep, while the smaller lake is a little deeper, about 400 meters.

This crater has been inactive at least since the dawn of Philippine history. The only activity in the district on record was volcanic emanations from a small craterlike vent on the southeastern slope of the Cuernos de Negros, some 16 kilometers from Dumaguete, in a locality called Magaso. The continued inactivity is also evidenced by the fact that three or four small streams have already developed on the sides of the crater. It would appear that the lava of the chimney had consolidated into a volcanic plug, thus closing the bottom of the crater and permitting more accumulation of surface waters due to the fact that there was less seepage. Further testimony along this line of evidence is offered by Doctor Herre's observations as follows:[1]

* * * The rocks where, up to two years ago, one formerly embarked, at the point where the lake is approached, are now submerged about 5 meters, and are 15 meters or more from the present shore line.

Next to the water line was a belt of tree ferns ranging in height up to 5 or 6 meters and occupying the strip almost to the entire exclusion of other woody plants. These tree ferns have been killed by the rise in the water and now but a few dead ones, partially or totally submerged, are to be seen. * * * Since tree ferns are very slow-growing plants and live for centuries, it is likewise evident that the water line was for a long time much lower than it is at present.

Nearly all the streams in this part of Negros flow radially from near the central mass to the coast. In the gorge of one of these streams, in Ocoy River, a few kilometers north of Dumaguete, are hot springs. It will be remembered that hot springs, generally connected with uncooled masses of siliceous lava, are usually regarded as representing the last expiring stage of volcanic activity. There are no large rivers, and the streams are of nearly the same size and at about the same stage of development. The upper section of the streams consists of rapid waters capable of effective erosive work, while the lower section is sluggish and meandering, bordered by flood grounds.

[1] Smith, Warren D., Geology and Mineral Resources of the Philippine Islands, Bureau of Science Pub. 19 (1924) 176.

The coastal plain is variable in development. In the region of Bais and Tanjay is a broad expanse of level land formed by flood plain and alluvial deposits of the Panambalon, Tanjay, and other rivers in a partly inclosed mountain valley. The coastal plain is at its maximum development in this region but becomes narrower southward to Dumaguete, and when Zamboanguita is reached it is merely a narrow strip of land. From Zamboanguita to Siaton the coastal plain is practically nonexistent. At Siaton the Siaton and Canauay Rivers have formed a small flood-plain deposit. From here to Tolong Viejo the hills are very close to the sea. At Tolong Viejo and Bayuan (Tolong) the physiographic counterpart of the Bais and Tanjay region is present, in which a partly inclosed mountain valley opening into the sea is filled with flood plain, alluvial fan, and delta deposits of the Bayuan, Sicopon, and other rivers.

The prevailing country rock of the hills and mountains is andesite, andesitic basalt, and normal basalt, representing different stages of volcanic flow. In a few places the weathered andesite resembles tuff. The saddle connecting the Cuernos de Negros with the main cordillera of Negros Island is composed in the main of volcanic tuff and other materials.

The geologic history of southeastern Negros can be briefly summarized as follows: A volcanic island, formed by successive volcanic eruptions, gradually increased its cone by continued eruptive activity, which may have begun late in the Miocene. In the course of the continued activity parasitic cones developed on the flanks and sides, and at times there was probably abnormal violence or collapse which destroyed the symmetry. It appears that there were also mud flows which buried older bowlders and gravels. In the cañon of Ocoy River rounded volcanic bowlders and pebbles can be seen embedded in the nearly vertical sides. The volcanic activity continued probably until late Pliocene, when the last product came in the form of ashes and dust which were afterward consolidated into tuff. With the cessation of eruptive activity began the formation of radial streams and gullies, and the more or less circular crater, now known as Lake Balinsasayao, began to fill with water. As the different cones were worn away by denudation, flood plain, alluvial, and delta deposits were formed, particularly in the mountain valley at Bais and Tanjay and across the peninsula at Bayuan (Tolong) and Tolong Viejo. The materials composing these river plains are in the main unconsolidated sediments, sand, gravel, and tuffaceous clay. The last stage in the history of

southeastern Negros is the building up of fringing coral reefs along the coast, more particularly at those places where the swampy condition of the streams and the water-borne sediments do not interfere with the growth of corals.

EFFECTS OF THE EARTHQUAKE

With a knowledge of the general geology and geologic history of southeastern Negros it is not difficult to understand the selective destruction by the earthquake of May 5, 1925. The regions that suffered greatest destruction will be briefly described.

Bais.—The sugar central of the Compañia Tabacalera suffered great damage. At the main plant the steel columns supporting the tanks and evaporators were badly bent. While the earthquake shocks were in the main responsible for the damage, it is true that the loads were rather heavy for the supports and that substantial bracing with diagonal struts might have overcome the inertia of the loads during the horizontal movements. The other structures of the sugar central stood the vibrations well. However, a concrete pier belonging to the central was badly damaged. The columns supporting the pier had been driven in mud but there was no bracing of any kind. After the earthquake the floor of the pier was found inclined and all the columns were broken at the junctions that had no reënforcing knee braces. The mud into which the columns had been driven was so soft that afterward, by strong pulling, the pier was returned to its horizontal position. A concrete pier on mud foundation can hardly be expected to resist horizontal oscillations. Sections of the long causeway leading to the pier subsided, but these sections had rested on mud; the portions built on coral banks were not damaged.

Tanjay.—The Catholic church of Tanjay lost its magnificent-appearing front flanked by two high bell towers. The façade was constructed of a filling of mortar and soft stone with a thin facing of coralline limestone. It appears that the contractor embedded big wooden posts in an upright position in the corners of the towers. After the posts had decayed, they left empty spaces. The ruins also showed that the mortar was soft and porous, and that water, fungi, and plant roots had penetrated into the apparently massive work. It is not known why the contractor embedded the big posts; possibly, he believed they would serve as reënforcements. This practice, however, is not to be recommended because, with the disappearance of the posts

by decay (which is to be expected), the whole structure is weakened, and before they disappear their vibrations tend to smash the surrounding mass. The convent of Tanjay, the municipal building, and several private houses built of wood suffered damage, but it was found that these were greatly in need of repairs and some of the posts had already been eaten by the destructive termites (*anay*).

Bayuan (*Tolong*).—Portions of the cane fields were raised and numerous cracks appeared in the ground, some of them large enough to admit carabaos and so deep that three or four of the carabaos that fell into the cracks had to be killed as they were unable to get out. Numerous coconut trees were uprooted and several were torn apart by the movement. The old chimney of the sugar mill tumbled at the first quake. Most of these chimneys (chimneys were damaged also in other places affected by the earthquake) were constructed of ordinary bricks or adobe stone, piled and held together by weak mortar and, after years of exposure, they were exceedingly weak and could not resist even slight oscillations.

Siaton.—The Catholic church, which was of stone construction, was badly damaged. The walls were built of smooth, round, river pebbles and weak mortar. The rather elaborate, arched front door had no arching properties and the whole arch structure fell at the first sign of movement. The supports, or piers, remained standing and were apparently able to withstand the shocks. The walls of the ground floor of the convent, built of similar river pebbles, were razed to the ground. The ruins formed a heap of clean pebbles and bits of mortar. All structures in the town that were built of the same materials, fortunately few, were ruined. The municipal building, of mixed construction consisting of concrete posts with wooden framing and roof trusses covered by a corrugated steel roof, suffered much damage. The concrete pillars, not braced together, supported the rest of the wooden structure and were broken at the junctions with the floors and the roof framing. The public school building, which likewise had concrete pillars with wooden beams, was also damaged; all of the pillars were broken at their bases. It appears that mixed construction of the kind mentioned will not vibrate consonantly as a single unit.

Other towns.—With the exception of slight damage in Zamboanguita, the rest of the towns in the district showed no signs of having been through an earthquake. The earthquake was

felt in Bacong and Dumaguete, but no damage was sustained there.

Landslides and cracks.—From Siaton, Zamboanguita, and other places can be seen the scars of a number of large landslides on the sides of Cuernos de Negros. These are in the main due to earthquakes, but the immediate cause must be the effect of rain water which serves as a lubricant to the shaken mass. Shortly after the Cebu earthquake of 1922 an extensive landslide occurred on the side facing Zamboanguita, which destroyed caiñgin fields and swept away a man and a carabao plowing near the edge of the gulch; according to report, the man escaped without serious injury. Sometime after the earthquake of May 5 an extensive landslide occurred on Mount Gilagaon, which buried two or three houses, killing some twenty people.

The provincial roads were badly cracked and damaged in the parts built across inundated mangrove swamps; these parts subsided in several places. Due to the soft foundation the road materials tended to spread out, causing wide, lengthwise fissures. On the trail from Pamplona near Tanjay, across the peninsula to Bayuan, were numerous landslides and cracks; one particularly large crack, encountered before the sitio of Amio was reached, was a meter wide, some 50 meters long, and of unknown depth.

ORIGIN AND PROBABILITY OF RECURRENCE

The origin of the Negros earthquake of 1925 was the movement of the earth's crust along a seismotectonic line (marked GG on the map) extending from northwestern Samar and Leyte, crossing southeastern Negros in the region of Bais, Tanjay, and Bayuan (Tolong), and probably terminating west of Zamboanga Peninsula. The periodic movements were simply the result of readjustments of the land masses, which occur whenever there is sudden relief of strain when these pass the limit of equilibrium and the modulus of elasticity of the crust of the earth. The seismotectonic line marks in a general way the line of the fault, and movements along the fault plane take place whenever the stress exceeds the force of adhesion. It is not probable that earthquakes of greater intensity than that of the May earthquake will visit the district. Numerous slight shocks may be expected from time to time, as there are many places all along the fault line that do not show topographic adjustment, and there will probably be occasional tremors. It appears that this fault line is a broken line, and readjustment of the masses does not take

place along an extended area. This assumption is confirmed by the fact that little or no effect was noted in other sections of the line northeast and southwest of Oriental Negros.

SUMMARY AND CONCLUSIONS

The earthquake of May 5, 1925, was of geologic, or tectonic, nature and, in our opinion, not so strong as some observers in the district would have us believe. The earthquake intensity was Grade VIII in the Rossi-Forel scale, which is described as "very strong shock, *fall of chimneys, cracks in walls of buildings.*"

In general, the destruction was not so much due to the earthquake as to faulty construction and want of repairs. The construction of high walls with smooth round pebbles and the use of poor materials were in the main responsible for the destruction of the stone buildings. Large wooden posts embedded in stone walls cannot be expected to play the part of reënforcing steel. It appears that buildings of concrete posts and wooden frames and floors are very poor earthquake-resistant structures, as they do not vibrate as a unit. The heavy loads placed on the upper structures of the sugar centrals require much heavier and more substantial supports and braces.

Sections of roads constructed by filling up portions of muddy inundated areas are easily damaged by earthquakes, on account of the soft foundation. Any road the materials of which are not properly pressed and rolled heavily to the very base will develop cracks upon being subjected to earth movements.

The most serious damage by the earthquake occurred in the region of Bais, Tanjay, Bayuan (Tolong), and Siaton, where the surface rocks are unconsolidated sedimentaries, a mixture of sand, clay, and gravel. In Dumaguete and Bacong, where the surface rocks consist in the main of volcanic extrusives, little or no damage occurred, although the earthquake was undoubtedly felt with equal intensity.

ILLUSTRATIONS

PLATE 1

FIG. 1. Tanjay church after the earthquake.
2. Fissures in the provincial road, 1 kilometer south of Polo Barrio, municipality of Tanjay.

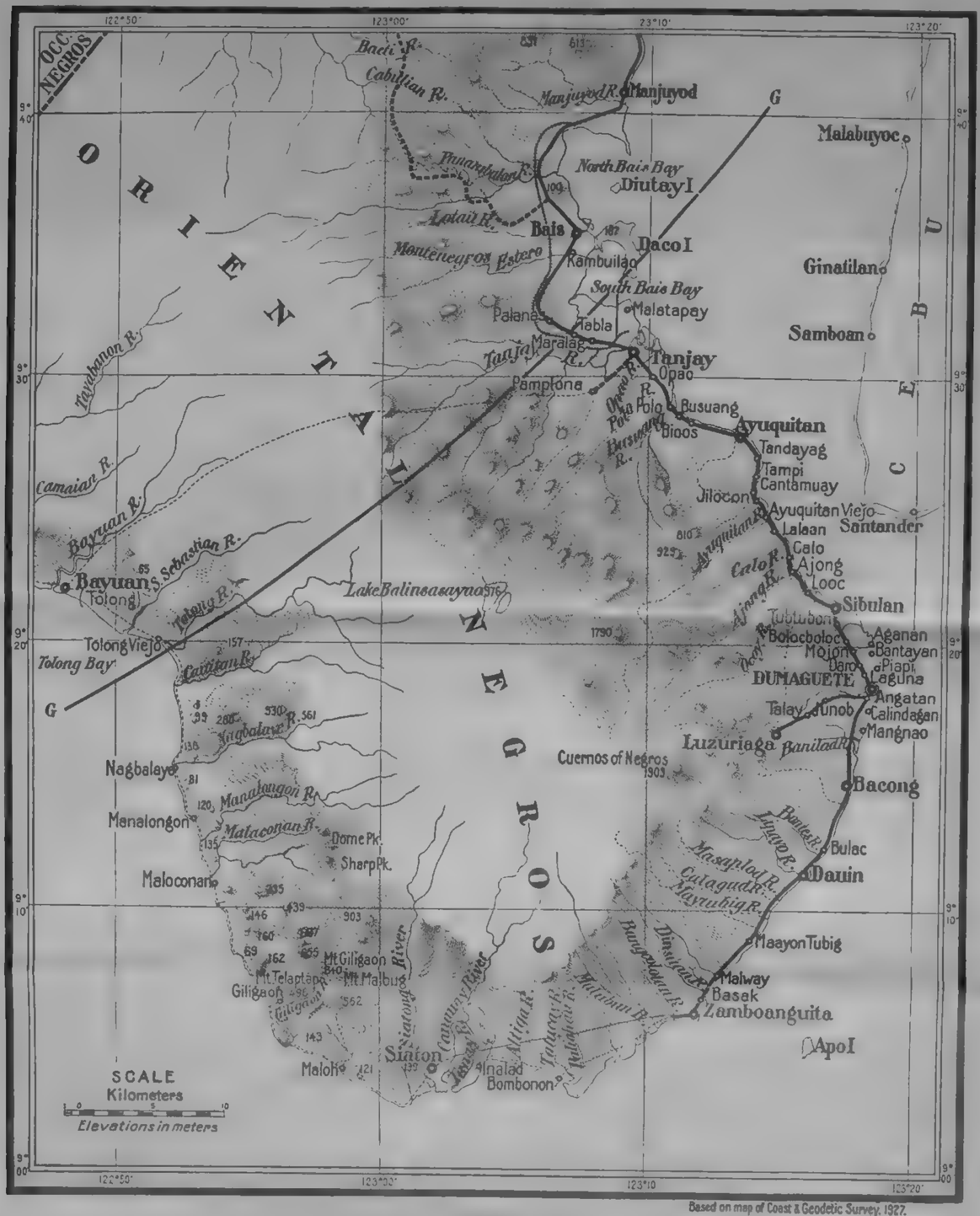
PLATE 2

Map of southern Negros.

1

2

PLATE 1.



Based on map of Coast & Geodetic Survey, 1927.

PLATE 2. SOUTHERN NEGROS.

ALCOHOL ADDITION PRODUCTS OF THE BROMO DERIVATIVE OF MIXED ETHERS AND BROMO DERIVATIVE OF DIPHENYL-ISOPROPYL ETHER

By D. M. Birosel

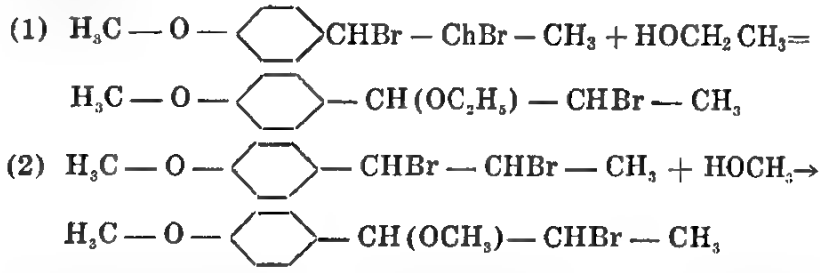
Chemist, Bureau of Science, Manila

Several studies have appeared in the chemical literature on the action of methyl and ethyl alcohols upon the bromo derivatives of propenyl compounds in which the carbon atom of the side chain is directly attached to the benzene nucleus, such as the bromo derivatives of anethol, isosafrol, and isoapiol and analogous compounds. It has been found that, when they are boiled with alcohols, they are converted into compounds containing a lower percentage of bromine than is contained in the starting material.

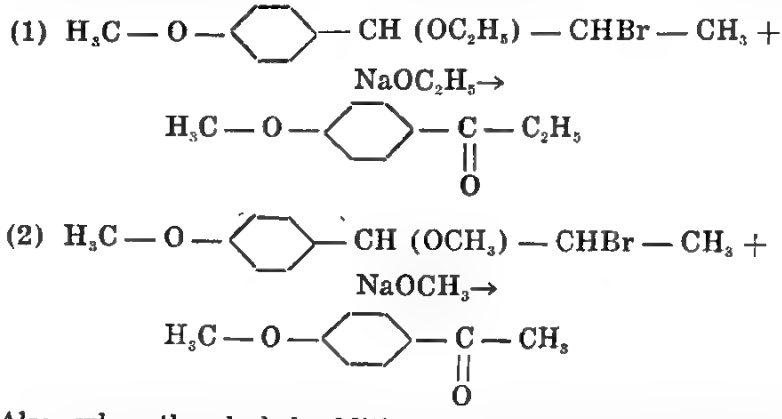
Hell and Gunthert [1] found that anethol dibromide is changed into a product containing less bromine, which they designated as *p*-*a*-bromo-*p*-ethoxypropyl anisole. Ciamician and Silber [2] found that monobromisosafrol is changed by boiling with ethyl alcohol. Hell and Hoering [3] stated that a noncharacteristic oil is formed when monobromisosafrol dibromide is boiled with ethyl alcohol. Pond and Shoffatall [4] converted anisilidine acetophenone dibromide into methyl or ethyl addition products when they boiled it with either methyl or ethyl alcohol. Orndorff and Morton [5] prepared an alcohol addition product of anethol by causing a slight excess of alcoholic potash to react with anethol hydrochloride. Strauss [6] reported having obtained 1,4-diphenyl-1,2-dimethoxy-3-butene by boiling diphenyl butadiene dibromide with methyl alcohol. Pond, Erb, and Ford [7] prepared the methyl and ethyl addition products of monobrom anethol by boiling

[1] Journ. Prakt. Chem. 52: 199.
[2] Berichte 23: 1164.
[3] Inorg. Diss. (Roslock) (1897) 59.
[4] Journ. Am. Chem. Soc. 22 (1900) 668–670.
[5] Journ. Am. Chem. Soc. 23 (1900) 181.
[6] Berichte 42 (1909) 2866.
[7] Journ. Am. Chem. Soc. 24 (1902) 329.

anethol dibromide with the corresponding alcohol represented as follows:



They converted these products into anisyl ethyl ketone and anisyl methyl ketone by treatment with either sodium ethoxide or sodium methoxide represented as follows:



Also, when the alcohol addition products of monobrom anethol are treated with alcoholic potash, the corresponding keto compounds are obtained. Pond and Wallach [8] likewise obtained these ketones by treating the dibromide with two molecular proportions of either sodium ethoxide or sodium methoxide. Hell and Hallenberg [9] also obtained these ketones. These keto bodies proved that the alkoxy group is attached to the carbon atom attached or nearest to the benzene nucleus which explains the easy formation of these ketones. The work of Tiffenenou and Daufresne [10] showed that the bromine atom nearest the phenyl radical in compounds of the type $Ar\text{-}CH_2CHBr\text{-}CH_2Br$ can easily be replaced by a substituting group such as the hydroxyl or acetyl or other radicals.

[8] Berichte 28: 2718.
[9] Berichte 29: 688.
[10] Compt. Rend. 144 (1907) 924.

The action of the alcohols on the bromo derivatives of mixed ethers has not been studied. Fairbourne and Toms [11] reported 2,4-dinitrophenyl β,γ-dibrompropyl ether, but they have not studied the effect of methyl or ethyl alcohol on their compound. Raiford and Colbert [12] repeated Fairbourne's work and obtained the same result, but did not try the action of alcohols on their compound. Claisen [13] and his students studied extensively phenyl allyl ether and its isomeric compound allylphenol, but their numerous papers contain nothing on the subject under consideration.

No work is on record which treats of the action of the alcohols upon the bromo derivatives of alkylene compounds in which the alkyl group is not directly attached to the benzene nucleus, such as the bromo derivatives of phenyl-allyl ether, phenyl-butylene ether, etc.

While working in Raiford's laboratory [14] I found that, when the bromo derivative of phenyl allyl ether and the bromo derivative of allylphenol are treated with absolute alcohol, compounds poorer in bromine content are obtained. When 4,6-dibromphenyl-β,γ-dibrompropyl ether was treated with absolute ethyl alcohol, a compound was obtained in which both of the bromine atoms on the alkyl group were replaced by two ethoxy radicals; 4,6-dibromphenyl-β,γ-diethoxypropyl ether was obtained. Only one atom of bromine in the alkyl radical was substituted in the case of 2-(β,γ-dibrompropyl)-4,6-dibromphenol when the compound was treated with absolute ethyl alcohol; 2-(β-ethoxy-γ-monobrompropyl)-4,6-dibromphenol was prepared. It was also found that absolute methyl alcohol gives analogous reaction.

So far as I am aware, no work of this nature has been reported in the chemical literature which treats of the action of the alcohols upon the bromo derivatives of phenylisoalkyl ethers. Raiford and Birosel [15] have not extended their work upon this group of compounds. The present study was undertaken with the view to find out whether this effect of the alcohols upon the bromo derivatives of phenylallyl ether is a general reaction and to extend further the study of these mixed ethers.

The behavior of mixed ethers in which the alipathic radical contains a secondary or a tertiary carbon atom has received

[11] Journ. Chem. Soc. 119 (1921) 1038.
[12] Journ. Am. Chem. Soc. 48 (1926) 2652–2662.
[13] Berichte 45 (1912) 3157; Ann. 401 (1913) 21; 418 (1919) 69.
[14] Birosel, Dissertation, Iowa (1926).
[15] Dissertation, Iowa (1926).

very little attention. Some of these compounds have been synthesized, but the action of bromine on them has not been reported.

Hautzsch and Vock,[16] following the method of Remsen,[17] obtained phenyl isopropyl ether when they treated diazonium chloride with ten times the theoretical amount of secondary alcohol. Riess [18] reported having obtained phenyl-isobutyl ether when he digested together equivalent amounts of phenol, isobutyl bromide, and potassium hydroxide in alcoholic solution. Bamberger [19] also obtained phenyl-isobutyl ether by digesting phenol, isobutyl iodide, and alcoholic solution of potassium hydroxide. Orndorff and Hopkins obtained phenyl isoamyl ether by Remsen's method, which calls for the decomposition of diazonium chloride by isoamyl alcohol and the formation of the ether.

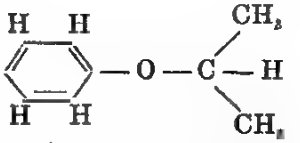
In their work with the mixed ethers, Raiford and Birosel found that the modified Claisen's method was applicable in the synthesis of the phenylisoalkyl ethers. Claisen recommended that a half mole each of the alkyl halide, phenol, and potassium carbonate be digested in 100 cubic centimeters of acetone in a 500-cubic-centimeter flask fitted with a reflux condenser in eight hours over a water bath. Raiford and Birosel recommend that, instead of a monomolecular proportion, a little excess of the alkyl halide and potassium carbonate and the same weight of acetone as that of phenol should be used and digested with a reflux condenser at the boiling point of the acetone. This they found to work better. By this method they synthesized phenyl isoalkyl, 2,4-dibrom phenyl isopropyl, and 2,4,6-tribromphenyl-isopropyl ethers. Starting with these three compounds they obtained 2,4,6-tribromphenyl-β-monobromisopropyl ether by direct bromination in chloroform solution.

A review of the literature will show that the halogen atom attached to the benzene ring is not affected by boiling the substance with alcoholic solution of potassium hydroxide. The work of Hell and Gunthert on monobromanethol dibromide, the work of Ciamician and Silber [20] on monobromisosafrol dibromide, and the work of Raiford and Birosel on 2,4-dibrom-phenyl-β,γ-dibrompropyl ether and 2-(β,γ-dibrompropyl)-2, 4-dibromphenol, etc., show that only the halogen atom on the alkyl is affected by alcoholic solution of potassium hydroxide.

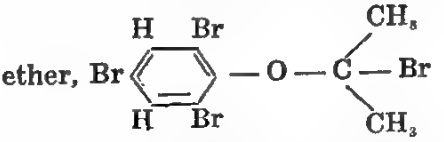
[16] Berichte 36 (1903) 2061.
[17] Journ. Am. Chem. Soc. 11: 291.
[18] Berichte 3 (1886) 780.
[19] Berichte 19 (1886) 1820.
[20] Berichte 23: 1164.

It is expected therefore that the alkoxy group attaches itself to the carbon where the halogen atom formerly attached itself. In the case of 2,4,6-tribromphenyl-β-monobromisopropyl ether, only the β-bromine atom is replaceable by the alkoxy group. Hence, when this bromo compound is treated with ethyl alcohol 2,4,6-tribromphenyl-β-ethoxyisopropyl ether is the compound prepared.

EXPERIMENTAL

p-Bromphenyl isopropyl ether, 

By starting with *p*-bromphenol, I prepared *p*-bromphenyl isopropyl ether.[21] Twenty-four grams of *p*-bromphenol were digested with 5 per cent excess of the theoretical amount of isopropyl iodide, potassium carbonate, and 24 grams of acetone for several hours at the boiling temperature of acetone. After digestion, the reaction flask was cooled, an equal volume of water and ether added, and the mixture shaken vigorously. The ethereal solution was separated by means of a separatory funnel and shaken vigorously with excess 10 per cent sodium hydroxide solution to remove unchanged *p*-bromphenol. The ether solution was separated and dried with potassium carbonate. The petroleum ether solution was filtered and the solvent distilled off. The residue distilled over at 155 to 165.22° millimeters. It boiled at 236°, hence the compound must be the same as the *p*-bromphenyl-isopropyl ether which was reported by Silva.[22]

2,4,6-Tribromphenyl-β-monobromisopropyl ether, 

Thirty-five grams of the *p*-bromphenyl isopropyl ether were dissolved in chloroform. A great excess of bromine solution in chloroform was slowly added while the ether solution was being stirred vigorously. The solution became hot on addition of the bromine solution and it was sometimes necessary to cool the reaction flask in ice water. A cloud of hydrobromic acid was given off on each addition of bromine solution. The reac-

[21] This synthesis was undertaken in the University of Iowa after I had submitted my dissertation to the Graduate School.

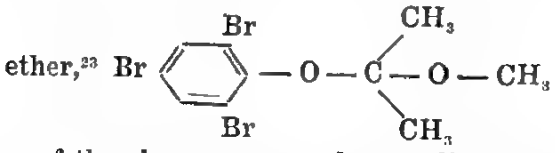
[22] Zeitschrift für Chemie (1870) 250.

tion flask was laid aside for three days under the hood to complete the reaction. After that time the solvent was distilled off, the excess bromine also going off with it.

The needle crystal obtained was recrystallized several times from petroleum ether and a perfect white needle crystal melting point with the compound prepared by Raiford and Birosel gave 93° C. This compound is no doubt the same as the 2,4,6-tribromphenyl-β-monobromisopropyl ether obtained by them. Analysis for the bromine content of the compound gave the following figures:

	Carius.		Modified Meulen.[23]	
	A	B	A	B
Weight of substance used	0.1477	.1322		
Weight of AgBr	0.2460	0.2195		
Found, per cent	70.81	70.75	70.65	
Calculated from $C_9H_8OBr_4$, per cent		70.78		

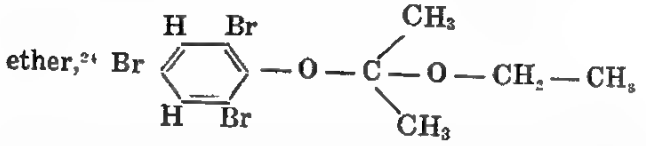
2,4,6-Tribromphenyl-β-methoxyisopropyl ether,[23]



Ten grams of the above compound were digested with excess methyl alcohol in a 200-cubic-centimeter Erlenmeyer flask fitted with an air condenser. Silver nitrate was added. Silver bromide was deposited at the bottom of the flask. Digestion was continued for several hours. The excess alcohol was distilled off and then equal volumes of water and petroleum ether were added. The ethereal solution was separated and washed several times with water to eliminate alcohol entirely from the product. The solvent was distilled off and the residue put under vacuum for a long time to remove the solvent completely. A brown reddish viscous liquid was obtained. This was left several days on the table and a crystal was formed which melted at 118 to 120° C.

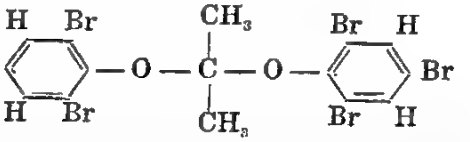
[23] This modified Meulen's method of analysis of halogen by combustion is due to the work of F. L. Smith, Philip. Journ. Sci. 32 (1927) 315. The figure obtained by this method checks favorably with those obtained by the Carius method and with the calculated figure. This method under an expert analyst has the advantage over the Carius method that it consumes less time. Thanks are due to Miss Irene Santos, assistant in chemistry, University of the Philippines, who kindly undertook this check analysis. The figures under Carius were obtained after I had undertaken about fifty analyses on the bromo derivatives of mixed ethers in the laboratory of Dr. C. L. Raiford, State University of Iowa.

2,4,6-Tribromphenyl-β-ethoxyisopropyl ether,[24]



Ten grams of 2,4,6-tribromphenyl-β-monobromisopropyl ether were digested as above with absolute ethyl alcohol for several hours. The 200-cubic-centimeter flask was cooled and equal volumes of water and petroleum ether were added and the mixture was shaken vigorously. The petroleum ether solution was separated and was washed several times with water, to remove excess of ethyl alcohol. The petroleum ether solvent was distilled off and the residue subjected to pressure for several hours. A brown reddish viscous liquid was obtained which, when laid aside for several days, gave crystals which melted at 130 to 132° C. This compound is soluble in most organic solvents and to some extent in water. Hydrolysis with sulphuric acid and testing the steam distillate for ethyl alcohol produced a positive iodoform text. The product obtained by the action of ethyl alcohol on 2,4,6-tribromphenyl-β-monobromisopropyl ether is 2,4,6-tribromphenyl-β-ethoxyisopropyl ether, and when methyl alcohol is used, 2,4,6-tribromphenyl-β-methoxyisopropyl ether is produced.

β(-2,4,6-Tribromphenyl)-β(-2,4,6-tribromphenyl)-isopropyl ether,



Six grams of phenol were treated with less than the required amount of 2,4,6-tribromphenyl-β-monobromisopropyl ether for a monomolecular proportion. Excess potassium carbonate was added to the acetone solution; the amount of solvent used was equal to the weight of the phenol. The mixture was digested for several hours at the boiling temperature of acetone. When the mixture was cool, equal volumes of water and petroleum ether were added and the mixture was shaken vigorously. Three layers were obtained; namely, aqueous, petroleum, and oil. The oil was separated and dried. It solidified and was dissolved in petroleum ether. It recrystallized in fibrous crystals. It melted

[24] The material here used was brought from the United States. These experiments were undertaken in the organic laboratory of the Bureau of Science.

at 125 to 130° C. and decomposed at over 140° C. The compound [25] gives a black residue when burned. It does not dissolve readily in chloroform but when bromine solution in the same solvent is added it dissolves readily, giving potassium bromide precipitate which collects at the bottom of the flask, and at the same time hydrogen bromide is also given off. The solution is laid aside for three days to complete the reaction, and at the end of this time the precipitate is filtered and the solvent and excess bromine are distilled off. Recrystallization of the solid residue from petroleum ether yields white needle crystals which melt at 86.5° C. A mixed melting point with 2,4,6-tribromphenyl-monobromisopropyl ether was taken and 88° C. was read. Analysis for bromine content shows the following figures:

0.0513 gram of substance gave 0.0823 gram of dry AgBr.
0.0511 gram of substance gave 0.0821 gram of dry AgBr.

	Per cent.
Found	68.37 and 68.27
Calculated from $C_9H_{10}O_2Br$,	68.35

SUMMARY

1. The effect of the alcohols encountered by various workers upon the bromo derivatives of propenyl compounds in which the side chain is directly attached to the benzene ring is found to be a general reaction upon the bromo derivatives of *n*-alkyl compounds; it is also applicable in compounds in which the side chain is connected with an oxygen atom attached directly to the benzene nucleus.

2. The compound 2,4,6-tribromphenyl-β-monobromisopropyl ether was prepared by direct bromination in chloroform solution of *p*-bromphenyl isopropyl ether.

3. Alcohol addition products, 2,4,6-tribromphenyl-β-methoxyisopropyl ether and 2,4,6-tribromphenyl-β-ethoxyisopropyl ether were prepared from 2,4,6-tribromphenyl-β-monobromisopropyl ether.

4. Also, β(-2,4,6-tribromphenyl)-β(2,4,6-tribromphenyl)-isopropyl ether was prepared.

5. A brief review of the literature upon the subject is given.

ACKNOWLEDGMENT

I take this opportunity to thank my former research instructor, Dr. C. L. Raiford, whose interest in my work under him aroused my interest in this study.

[25] It is hoped that this intermediate compound will be studied further to establish its structure, when the necessary chemical is available in the laboratory.

LIFE TABLES FOR THE NATIVE RESIDENT POPULATION OF THE CITY OF MANILA FOR THE YEAR 1920

By EUGENIO HERNANDO

Of the Philippine Health Service, Manila

SIX TEXT FIGURES

DESCRIPTIVE

The City of Manila is the capital of the Philippine Islands. It is situated on Manila Bay at the mouth of Pasig River, and occupies an area of 36 square kilometers of lowlands. Pasig River runs through the city, dividing it into two parts. The oldest part lies to the north of the river and is inhabited by the Chinese and other laboring classes of the city. This district is not so well improved as is that located to the south of the river, which is almost exclusively residential in character and is inhabited by the well-to-do Filipino and the white population of the city. Only about one-third of the area of the City of Manila is provided with sanitary sewerage. The pail system is used in the area without sewerage, and in this area there are about three hundred public closets.

Manila has two principal sources of drinking water; namely, the Metropolitan Water District supply (surface water) and thirty-five artesian wells scattered throughout the city.

The surface water is taken from Montalban River, which is protected by restriction of the water shed. During the dry season, water is taken also from Mariquina River. The water from these rivers is stored in reservoirs; that from the Montalban in a modern, open, 55,000,000-gallon basin and that from the Mariquina in an old covered reservoir of 19,000,000 gallons capacity. It is estimated that the daily consumption of water in the City of Manila is about 23,000,000 gallons, of which artesian wells furnish about 170,000 gallons.

City water is treated raw by calcium hypochlorite at the rate of from 0.05 to 0.06 part available chlorine per million parts of water, depending upon the degree of turbidity of the water. This is the only treatment received by the water before it reaches the public.

The mean annual temperatures of the city are 21.9° C. minimum and 31.1° C. maximum. The average relative humidity is 79.5 per cent. There are two seasons during the year; namely, the rainy season, which begins in May and lasts until the middle of November, and the dry season, which prevails during the remaining months of the year. Each year during the rainy season some portions of the city are flooded.

The sanitary organization of the City of Manila is satisfactory enough, though the financial condition of the Municipal Government does not permit of permanent sanitary improvements or the sanitary engineering projects that such a large city needs; nevertheless, the general sanitary condition can be said to be fair.

STATISTICAL DATA

The population of the City of Manila is 283,613 distributed as shown in Table 1.[1]

TABLE 1.—*Population of the City of Manila by nationalities.*

Americans	3,134
Filipinos, including residents and transients	257,356
Spaniards	1,955
Other Europeans	1,126
Chinese	17,856
All others	2,186
Total	283,613

The native (Filipino) resident population was used for the construction of these life tables. By native population is meant all persons born in the Philippines of Filipino parents and those born of natives married to foreigners. The people born in the Philippines of foreign parents (both mother and father) were excluded from the native population. All natives who had resided in the city for more than one year were also considered to be residents. People from the provinces who had resided less than one year in the city were excluded.

These life tables were constructed as of July 1, 1920. The population at this time was calculated arithmetically, by taking as bases the populations given in the official census made in the years 1903 and 1918. Thus the population estimated as native and resident of the City of Manila on July 1, 1920, was 140,871 males and 130,450 females.

[1] Census of the Philippine Islands 2 (1918).

The basic figures of mortality data were the number of deaths reported for the years 1919, 1920, and 1921, in which years no epidemic or other special causes of death were registered which might affect the normal mortality of the city.

The mathematical process followed in the preparation of these life tables was that taught by Dr. Lowell T. Reed, of the Johns Hopkins School of Hygiene and Public Health.

Three life tables have been prepared; namely, one for males, one for females, and one for both sexes.

The expectation of life calculated for the native-born population of the City of Manila is compared with the expectation of life of Filipinos, Chinese, Japanese, and Hawaiians in Hawaii in 1920, and also with that of the colored population in the original Registration States in the United States in 1910.

Partial tables are also included in this paper for the purpose of comparing the values of qx (rate of mortality per thousand), lx (survivors) and $\mathring{e}x$ (expectation of life) of the racial classes mentioned in the preceding paragraph, the life table for both sexes having been selected for this purpose.

The values of qx, lx, and $\mathring{e}x$ pertaining to the Filipinos, Chinese, Japanese, and Hawaiians in Hawaii were taken from an article entitled Life tables for various racial groups in Hawaii [2] and the same values for the colored population, from the United States life tables.[3]

The Manila life tables of 1920 are not compared with the life tables of the colored population of the United States for the same year because a copy of the United States life tables of 1920 was not available.

The life tables for the native-born population of the City of Manila are compared with the life tables of Hawaii, because it is the only country in the world outside of the Philippines in which there is an organized Filipino colony of any size. From the last census of the Hawaiian Islands, the Filipino population in Hawaii in the year 1920 was 16,851 males and 4,180 females. As the climate of Hawaii is subtropical rather than tropical as in the Philippines, objection might be made to a comparison of the life tables for these two countries; but the differences in climate between Hawaii and the Philippines are too slight to invalidate such comparison.

[2] Hsien W. Kung, Am. Journ. Hyg. 6 (January, 1926).
[3] Bureau of Census, Washington, D. C. (1910).

On the other hand, the sanitary conditions in Hawaii are, according to available information, much better than those in the Philippines and especially those in the City of Manila. This being so, it is pertinent to inquire whether or not Filipinos increase their expectation of life when living under better sanitary conditions than they do at present in Manila.

UNAVOIDABLE ERRORS IN THE CONSTRUCTION OF THE LIFE TABLES

Before entering into the discussion of these life tables, it is necessary to point out some unavoidable errors in their preparation, in order that these may be taken into consideration in evaluating the results, although such errors are not of sufficient importance to alter the conclusions essentially.

The first error to be considered is that committed in the estimates of population as of July 1, 1920. No census was taken in 1920 and for this reason the population of the year 1920 was estimated by arithmetical computations, taking as bases the populations of the Census for the years 1903 and 1918.

The census taken in 1903 cannot be considered accurate, because at that time the Filipino Insurrection was so recent that the people, doubting the object of the census, did not coöperate and, as a consequence, a portion of the population was concealed and not enumerated. This fact conceded, it is evident that the population given in the Census for the year 1903 was entirely too low. In the Census for the year 1918 the population was much better enumerated, but this census coincided with the influenza pandemic which caused an increase in mortality for that year. However, despite these sources of error, it is believed that, in so far as the City of Manila is concerned, they are not of such magnitude as to alter substantially the final results.

The second unavoidable error is the distribution of population by age groups and the mortality registered in each group. The return by ages cannot be considered absolutely accurate because of a small proportion of illiterate people who were unable to furnish correct statements of their ages. This condition obtained in only about 5 per cent of the population of the city and this small number should not appreciably affect the values obtained.

DISCUSSION OF THE LIFE TABLES

Mortality.—Studying the values of qx in the life table constructed for the native-born population of the City of Manila, one is first impressed with the high infant mortality and the

fact that infant mortality is higher in males than in females. In fact, infant mortality for males is 275.02 against 192.55 for females. The mortality is higher also in males than in females in the groups of ages following the group 0–1 up to the group 26–27 when the mortality among females exceeds that among males. Beginning with the group of ages 52–53, the mortality among males is again higher than in females and this difference becomes greater and greater as age increases.

These results differ in certain particulars from those observed in other communities. It is true that in any community mortality is higher for males than for females during infancy and vice versa during puberty; but in old age, or after reaching the age of 50 years, although the difference is unfavorable to the males, this difference is not so pronounced as is the case for the native-born population of the City of Manila. This difference can be better observed by consulting fig. 1.

Table 2 has been prepared for the purpose of comparing the values of qx of the native-born population of the City of Manila with the same values for the Filipinos, Chinese, Japanese, and Hawaiian population of Hawaii and the colored population of the United States.

TABLE 2.—*Values of qx (mortality per 1,000).*

Population.	Age in years.				
	0–1	10	20	30	40
Filipinos in Manila, both sexes, 1920	215.38	6.04	8.74	13.06	16.79
Filipinos in Hawaii, both sexes, 1920	263.65	3.68	9.88	11.47	13.70
Japanese in Hawaii, both sexes, 1920	93.90	2.48	8.12	9.15	10.28
Chinese in Hawaii, both sexes, 1920	89.09	2.71	6.93	9.73	10.90
Hawaiians in Hawaii, both sexes, 1920	203.96	9.05	22.56	26.15	30.44
Colored people in United States in 1910:					
Males	219.35	5.02	11.96	14.96	21.03
Females	185.07	5.18	10.74	12.02	17.50

Population.	Age in years.				
	50	60	70	80	90
Filipinos in Manila, both sexes, 1920	23.06	40.13	84.55	186.90	400.49
Filipinos in Hawaii, both sexes, 1920	18.31	30.84	62.07	131.43	272.42
Japanese in Hawaii, both sexes, 1920	13.71	24.11	44.04	114.12	278.68
Chinese in Hawaii, both sexes, 1920	13.12	23.05	54.38	132.71	303.09
Hawaiians in Hawaii, both sexes, 1920	38.18	55.96	96.47	182.33	352.23
Colored people in United States in 1910:					
Males	31.42	50.79	83.98	131.27	201.01
Females	25.52	45.58	71 27	119.68	172.34

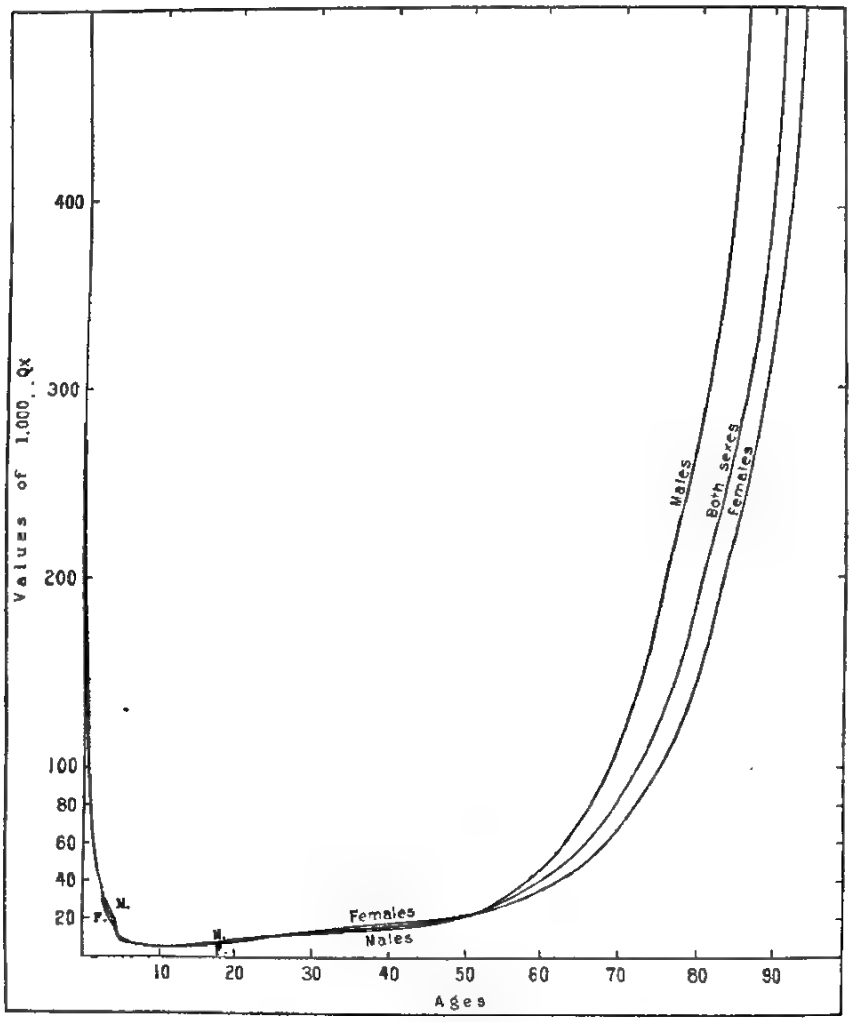


FIG. 1. Diagram of life table for native born in the City of Manila for 1920. Rate of mortality at age X.

The first fact to be noted in Table 2 is that the infant mortality among the native-born population of the City of Manila and among Filipinos in Hawaii exceeded that among Chinese, Japanese, and Hawaiians in Hawaii, and the colored population in the United States. Infant mortality is higher among Filipinos in Hawaii than among Filipinos in Manila.

Kung, referring to the high infant mortality of Filipinos in Hawaii,[4] said:

[4] Hsien W. Kung, Am. Journ. Hyg. 6 (January, 1926).

This extremely high infant mortality among the Filipinos is in all probability due to the peculiar racial characteristics and to their low social status, the majority of them belonging to the lower laboring classes.

If this be the case in Hawaii, how is the higher infant mortality among the native-born Filipinos in the City of Manila to be explained?

We know that, since 1920, infant mortality in the Philippine Islands, and especially in the City of Manila, decreased appreciably owing to extensive prenatal and postnatal education among expectant mothers. Taking this fact into consideration, the only explanation for the high infant mortality prior to 1920 is that it was due to the peculiar social rather than racial characteristics of mothers, the characteristics of improper feeding and care of babies and of subjecting them to insanitary surroundings.

The mortality figures in the other age groups are higher for the native-born population of the City of Manila than for the Filipinos, Chinese, and Japanese in Hawaii. The differences between the native-born population of Manila and the colored people in the United States are not significant, but the inflection of the curve for colored people in the United States is less pronounced.

Mortality in the native-born population of the City of Manila is lower than in the Hawaiian population up to the age group 70–80. From this age group on, mortality in Manila is greater than in any of the other racial groups. This is against the alleged longevity of Filipinos. (See fig. 4.)

Survivors.—Figure 2 shows the curve of the survivors at all ages for the native-born population of the City of Manila. Examination of this figure and of the lx values in Table 3, reveals that the hypothetical population of 100,000 males has dwindled to one-half at the age of 27 years, but in females such reduction is reached ten years later; the 100,000 male population disappears at the age of 93 and the female at the age of 101.

Table 3 and fig. 5 have been prepared for the purpose of comparison of the lx values of the native-born population of the City of Manila with the corresponding values for Filipinos, Chinese, Japanese, and Hawaiians in Hawaii and colored people in the United States.

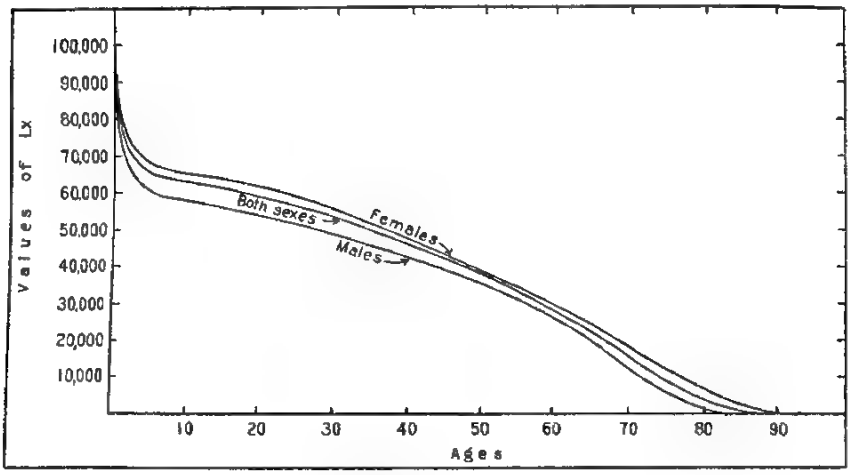


FIG. 2. Diagram of life table for native born in the City of Manila for 1920. Number of survivors at age X.

TABLE 3.—*Values of lx (survivors).*

Population.	Age in years.				
	10	20	30	40	50
Filipinos in Manila, both sexes, 1920	62,900	58,805	52,887	45,593	37,575
Filipinos in Hawaii, both sexes, in 1920	64,822	60,887	54,758	48,329	41,378
Japanese in Hawaii, both sexes, in 1920	84,678	80,812	74,109	67,304	59,962
Chinese in Hawaii, both sexes, in 1920	83,917	82,485	75,837	68,363	60,822
Hawaiians in Hawaii, both sexes, in 1920	67,132	57,588	45,103	33,965	24,175
Colored people in United States in 1910:					
Males	66,377	61,426	54,073	45,414	35,427
Females	70,508	64,764	58,281	50,368	40,886

Population.	Age in years.				
	60	70	80	90	100
Filipinos in Manila, both sexes, 1920	27,899	15,522	4,106	169	0
Filipinos in Hawaii, both sexes, in 1920	32,802	21,190	8,324	1,038	8
Japanese in Hawaii, both sexes, in 1920	50,237	36,730	17,826	2,458	13
Chinese in Hawaii, both sexes, in 1920	51,485	36,208	14,975	1,596	4
Hawaiians in Hawaii, both sexes, in 1920	15,263	7,258	1,795	100	0
Colored people in United States in 1910:					
Males	23,750	12,295	3,894	595	40
Females	28,908	15,871	6,324	1,206	112

In this study the survivors' curve in Manila falls below the survivors' curve for Filipinos in Hawaii, and both curves run above the survivors' curve for Hawaiians except for the age

group 0–1. This exception is due to the high infant mortality registered among Filipinos.

Also, it will be observed that the number of survivors among the colored people in the United States is greater than that among the Filipinos in Manila, although both lines coincide in the 50-to-70 age group. Up to the age of 40 the Filipino survivors in Hawaii are more numerous than are those in Manila or than in the colored population of the United States. The curve for the survivors among the Filipinos in Manila shows a more uniform and regular decline than does that of the Hawaiians.

Another feature observed is that the hypothetical population (both sexes) was reduced to one-half at the age of 34 years in the native-born population of the City of Manila, while this reduction was reached at the age of 37 years among the Filipinos in Hawaii, at 60 among Japanese, at 61 among Chinese, at 26 among Hawaiians, at 35 among colored males, and at 41 among colored females.

The total extinction of the hypothetical population (both sexes) occurred at the age of 98 among the native-born population in Manila, at the age of 104 among the Filipinos, Japanese, and Chinese in Hawaii, at 99 among Hawaiians, at 109 among colored males, and at 110 among females.

Expectation of life.—Tables 5, 6, and 7 and fig. 3 show the expectation of life for the native-born population of the City

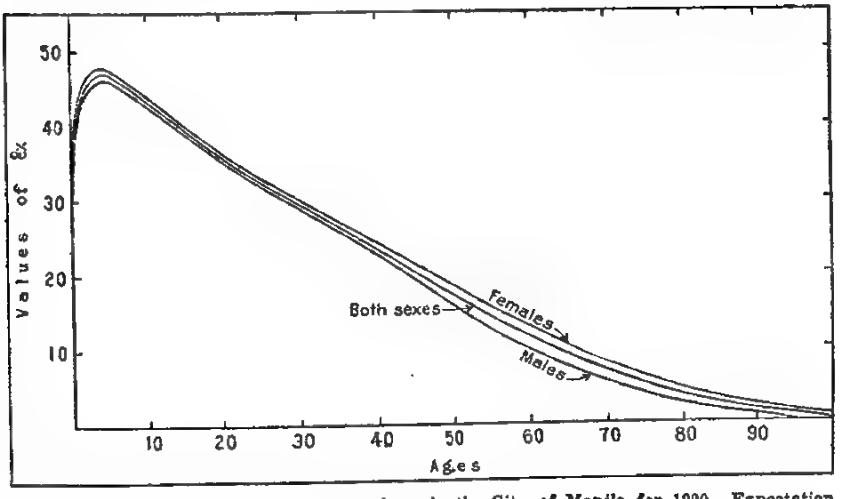


FIG. 3. Diagram of life table for native born in the City of Manila for 1920. Expectation of life at age X.

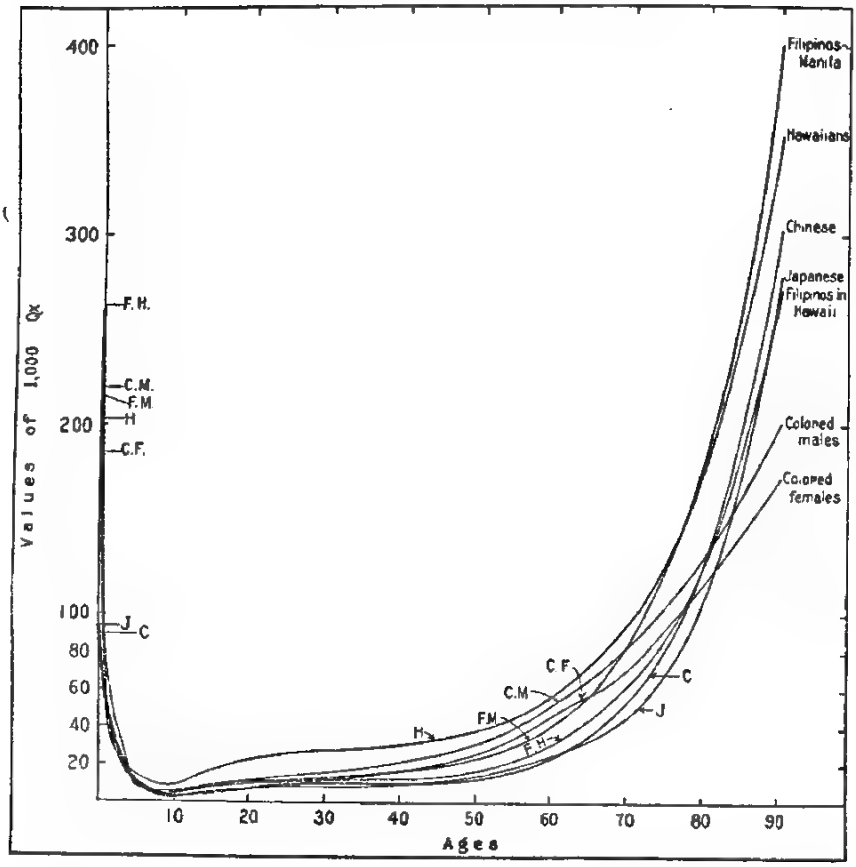


FIG. 4. Diagram of life tables for native born in the City of Manila and of Filipinos, Japanese, Chinese, and Hawaiians in Hawaii (both sexes) for 1920, and colored people (males and females) in the original registration states for 1910. Rate of mortality at age X.

of Manila for the year 1920. Table 8 and fig. 6 have been prepared for the purpose of comparison of the expectation of life of the native-born population of the City of Manila with that of the other populations considered in this paper.

The $\mathring{e}x$ values depending upon the qx and lx values, it is unnecessary to comment at length on the tables and charts mentioned. The first fact observed is that, as is the case in other countries, the expectation of life at all ages is higher among females than among males. Also, the expectation of life among the native-born population in the City of Manila is less at all ages than that of the Filipinos, Japanese, and Chinese in Hawaii; is greater than that of the Hawaiians; and approx-

imates that of the colored population of the United States in 1910. The expectation of life of the colored population in the United States was somewhat greater in 1920 than in 1910, so that the expectation of life of the native-born population of the City of Manila in 1920 was less than that of the colored population of the United States in the same year.

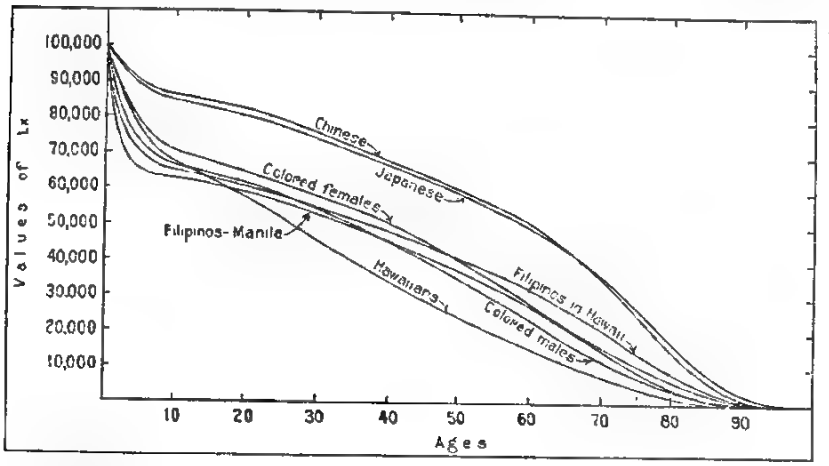


FIG. 5. Diagram of life tables for native born in the City of Manila and of Filipinos, Japanese, Chinese, and Hawaiians in Hawaii (both sexes) for 1920, and colored people (males and females) in the original registration states for 1910. Number of survivors at age X.

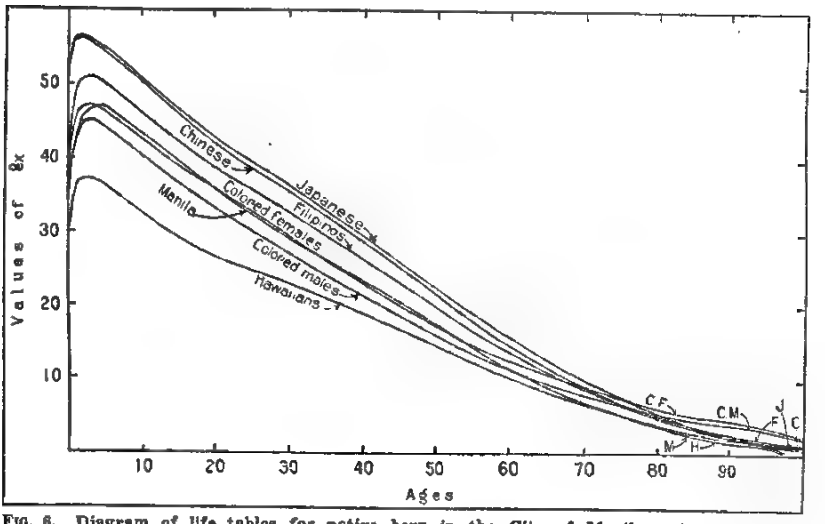


FIG. 6. Diagram of life tables for native born in the City of Manila and of Filipinos, Japanese, Chinese, and Hawaiians in Hawaii (both sexes) for 1920, and colored people (males and females) in the original registration states for 1910. Expectation of life at age X.

CONCLUSIONS

It is a fact that the expectation of life in a community, at least in the 0-to-40 age groups, increases in proportion to the sanitary improvements in that community. As a proof of this affirmation Table 4, showing the expectation of life for the white and the colored populations of the original Registration States in 1901, 1910, and 1920, is here presented. It is generally known that the major sanitary advances made in some parts of the United States were instituted after the year 1910.

TABLE 4.—*Expectation of life in the original Registration States, United States.*

	Year.	Age in years.		
		0	32	62
White males	1901	48.2	31.4	13 2
	1910	50.2	33.3	12 9
	1920	54.0	34.9	13 4
White females	1901	51.1	35.0	14.0
	1910	53.6	35.4	13.7
	1920	56.3	36.1	14.0
Colored males	1901	32.5	28.0	11.7
	1910	34.0	26.2	10.9
	1920	40.1	28.5	11.4
Colored females	1901	35 0	29.4	12.7
	1910	37.7	28.3	12.0
	1920	43.2	28.8	12.1

From this biometrical study of the native-born population of the City of Manila the following conclusions can be formulated:

1. That the expectation of life of the native-born population of the City of Manila is less at all ages than that of Filipinos, Japanese, and Chinese in Hawaii; equal to that of the colored population in the United States in the year 1910; and greater than that of the Hawaiians.

2. That the native population of the City of Manila, being constituted of various widely different social classes, while the Filipino population in Hawaii is for the most part imported for plantation work and other manual labor, should have, all other factors being equal, a greater expectation of life than the Filipinos in Hawaii.

3. The fact that the Filipinos in Hawaii enjoy a greater expectation of life than do their brethren in Manila, despite the

fact that, as a class, they are engaged in much harder labor, is probably due to the better sanitary environment in which they live.

4. If the expectation of life of the native-born population of the City of Manila be compared with that of the colored population in the United States, it might be concluded that the sanitary conditions of the native-born population of the City of Manila in the year 1920 was similar to that of the colored population of the United States in the year 1910, and inferior to that for the year 1920. However, there may be a racial factor involved here.

The notable increase in the expectation of life obtained in the United States, especially in the last fifteen years and in the 0-to-40 age groups, was undoubtedly largely due to the work of the sanitary engineer, and particularly to the purification of water supplies and to sewer and waste disposal. Protection of the food supply and improvement in housing conditions also contributed.

If advantage be taken of the experience of the countries most advanced in sanitary matters, the expectation of life of the native-born population of the City of Manila will be increased when municipal governments install permanent sanitary improvements such as the following:

A safer and more-adequate water supply. The chlorinization by calcium hypochlorite as the sole treatment of raw water is not sufficient to insure a safe water supply. A filtration plant and treatment of the filtered water with liquid chlorine are essential.

The extension of the sanitary sewer to all parts of the city and treatment of the sewage before discharge into Manila Bay.

Replacement of the present types of comfort stations with others of the flush type of closet.

Improvement in the collection and disposal of garbage, rubbish, and other refuse materials.

Improvement of the housing conditions and relief of the overcrowding to which the poor people are now subjected.

Establishment of public parks, especially for the benefit of children.

Filling in of the lowlands and dredging of the esteros.

Efficient sanitary control of food and drinks and correction of the present insanitary conditions in public markets.

An extensive and intensive program of sanitary education in schools, factories, workshops, and homes.

Improvement of the general diet of the population, especially by increasing the consumption of fresh milk by children.

TABLE 5.—*Life table for native-born males (1920) in the City of Manila.*

x to x + 1, age interval, period of lifetime between two exact ages.	Of 100,000 males born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginning of age interval.	o ex, expectation of life; average length of life remaining to those alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
0-1	100,000	27,302	273.02	31.16
1-2	72,698	6,344	87.27	41.67
2 3	66,354	3,036	45.76	44.61
3-4	63,318	1,906	30.10	45.72
4 5	61,412	1,440	23.45	46.12
5-6	59,972	476	7.93	46.22
6 7	59,496	441	7.42	45.59
7-8	59,055	416	7.04	44.92
8-9	58,639	397	6.78	44.24
9-10	58,242	386	6.62	43.54
10-11	57,856	379	6.56	42.82
11-12	57,477	379	6.59	42.10
12-13	57,098	381	6.68	41.38
13-14	56,717	388	6.84	40.65
14-15	56,329	397	7.05	39.93
15-16	55,932	408	7.29	39.21
16-17	55,524	420	7.57	38.49
17-18	55,104	434	7.87	37.78
18-19	54,670	448	8.19	37.08
19-20	54,222	461	8.51	36.38
20-21	53,761	470	8.75	35.69
21-22	53,291	489	9.17	35.00
22-23	52,802	505	9.57	34.32
23-24	52,297	520	9.94	33.65
24-25	51,777	532	10.28	32.98
25-26	51,245	542	10.58	32.31
26-27	50,703	581	11.46	31.66
27-28	50,122	592	11.82	31.02
28-29	49,530	602	12.15	30.38
29-30	48,928	609	12.45	29.75
30 31	48,319	616	12.74	29.11
31-32	47,703	621	13.01	28.49
32-33	47,082	624	13.26	27.86
33-34	46,458	627	13.50	27.23
34-35	45,831	629	13.75	26.59
35-36	45,202	631	13.96	25.95
36-37	44,571	632	14.19	25.31
37-38	43,939	634	14.42	24.67
38-39	43,305	635	14.67	24.03

TABLE 5.—*Life table for native-born males (1920) in the City of Manila*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	Of 100,000 males born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginning of age interval.	o ex, expectation of life; average length of life remaining to those alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
39–40	42,670	638	14.95	23.38
40–41	42,032	641	15.25	22.72
41–42	41,391	645	15.58	22.07
42–43	40,746	650	15.96	21.41
43–44	40,096	658	16.40	20.75
44–45	39,428	666	16.90	20.09
45–46	38,772	677	14.47	19.42
46–47	38,095	691	18.14	18.77
47–48	37,404	707	18 90	18.10
48–49	36,697	726	19.78	17.43
49–50	35,971	748	20 80	16.77
50–51	35,223	773	21.96	16.12
51–52	34,450	802	23.28	15.47
52 53	33,648	834	24.79	14.83
53–54	32,814	870	26.50	14.19
54–55	31.944	908	28.44	13.57
55–56	31,036	950	30.62	12.95
56–57	30,086	995	33.08	12.34
57–58	29.091	1,043	35.84	11.77
58–59	28,048	1,092	38.92	11.16
59–60	26,956	1,142	42.36	10.60
60–61	25,814	1,192	46.19	10.04
61–62	24,622	1,242	50.45	9.51
62–63	23,380	1,289	55.15	8.98
63–64	22,091	1,344	60.36	8.48
64–65	20,757	1,371	66.10	8.00
65–66	19,376	1,403	72.43	7.53
66–67	17,973	1,427	79.38	7.07
67–68	16,546	1,439	86.99	6.64
68–69	15,107	1,440	95.34	6.23
69–70	13,667	1,428	104.46	5.83
70–71	12,239	1,400	114.42	5.45
71–72	10,839	1,358	125.27	5.09
72–73	9,481	1,300	137.09	4.75
73–74	8,181	1,226	149.92	4.42
74–75	6,955	1,140	163.86	4.12
75–76	5,815	1,041	178.97	3.82
76–77	4,774	933	195.34	3.55
77–78	3,841	818	213.04	3.29
78–79	3,023	702	232.17	3.05
79–80	2,321	587	252.81	2.82
80–81	1,734	477	275.07	2.60
81–82	1,257	376	299.06	2.39
82–83	881	286	324.86	2.20

TABLE 5.—*Life table for native-born males (1920) in the City of Manila*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	Of 100,000 males born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginning of age interval.	o ex, expectation of life; average length of life remaining to those alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
83–84	595	210	352.62	2.03
84–85	385	147	382.44	1.86
85–86	238	99	414.44	1.69
86–87	139	62	448.78	1.55
87–88	77	37	485.57	1.40
88–89	40	21	524.98	1.25
89–90	19	11	567.16	1.11
90–91	8	5	612.26	1.00
91–92	3	2	660.47	0.83
92–93	1	1	711.96	0.50

TABLE 6.—*Life table for native born females (1920) in the City of Manila.*

x to x + 1, age interval, period of lifetime between two exact ages.	Of 100,000 females born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginning of age interval.	o ex, expectation of life; average length of life remaining to those alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
0–1	100,000	19,255	192.55	35.94
1–2	80,745	6,740	83.47	43.39
2–3	74,005	3,413	46.12	46.30
3–4	70,592	1,773	25.11	47.52
4–5	68,819	1,158	16.82	47.73
5–6	67,661	580	8.57	47.54
6–7	67,081	511	7.62	46.94
7–8	66,570	458	6.88	46.30
8–9	66,112	418	6.32	45.62
9–10	65,694	390	5.93	44.90
10–11	65,304	371	5.68	44.17
11–12	64,933	361	5.56	43.42
12–13	64,572	359	5.56	42.66
13–14	64,213	363	5.66	41.89
14–15	66,850	374	5.85	41.13
15–16	63,476	387	6.10	40.37
16–17	63,089	405	6.42	39.61
17–18	62,684	425	6.78	38.87
18–19	62,259	446	7.17	38.13
19–20	61,813	469	7.58	37.40
20–21	61,344	507	8.26	36.68
21–22	60,837	513	8.44	35.98

TABLE 6.—*Life table for native-born females (1920) in the City of Manila*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	Of 100,000 females born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginning of age interval.	o ex, expectation of life; average length of life remaining to those alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
22–23	60,324	542	8.98	35 28
23–24	59,782	569	9.51	34.60
24–25	59,213	592	10.00	33.93
25–26	58,621	613	10.46	33.26
26–27	58,008	678	11.69	32.61
27–28	57,330	703	12.26	31.99
28–29	56 627	725	12.81	31.38
29–30	55,982	746	13.34	30.74
30–31	55,156	764	13.85	30.19
31–32	54,392	780	14.34	29.61
32–33	53,612	793	14.80	29.03
33–34	52,819	805	15.25	28.46
34–35	52,014	816	15.68	27.89
35–36	51,198	824	16.10	27.33
36–37	50,374	831	16.50	26.77
37–38	49,543	837	16.89	26.21
38–39	48,706	842	17.28	25.65
39–40	47,864	845	17.66	25.09
40–41	47,019	848	18.03	24 53
41–42	46.171	850	18.42	23.98
42–43	45,321	852	18.80	23.42
43–44	44,469	854	19.20	22.86
44–45	43,615	855	19.61	22.29
45–46	42,760	857	20.04	21.73
46–47	41,903	859	20.50	21.16
47–48	41,044	862	21.00	20.60
48–49	40,182	866	21.54	20.03
49–50	39,316	870	22.12	19.46
50–51	38,446	875	22.76	18.89
51–52	37,571	882	23.47	18.31
52–53	36,689	890	24.25	17.74
53–54	35,799	899	25 12	17.17
54–55	34,900	910	26 08	16.60
55–56	33,990	923	27.16	16.03
56–57	33,067	938	28 36	15.46
57–58	32,129	954	29.70	14.90
58–59	31,175	972	31 18	14.34
59–60	30,203	992	32 84	13.79
60–61	29,211	1,013	34 68	13.24
61–62	28,198	1,035	36.72	12 70
62–63	27,163	1,059	38.99	12.16
63–64	26,104	1,083	41 49	11.63
64–65	25,021	1,108	44.27	11 12
65–66	23,913	1,132	47.34	10 61

TABLE 6.—*Life table for native-born females (1920) in the City of Manila*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	Of 100,000 females born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginnirg of age interval.	o ex, expectation of life; average length of life remaining to those alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
66-67	22,781	1,155	50 72	10 11
67-68	21,626	1,177	54.44	9 62
68-69	20,449	1,197	58 53	9.15
69-70	19,252	1,213	63 02	8 69
70-71	18,039	1,226	67 94	8 24
71-72	16,813	1,233	73 33	7 80
72-73	15,580	1,234	79 23	7 38
73-74	14,346	1,229	85.66	6 97
74-75	13,117	1,216	92 63	6 55
75-76	11,901	1,194	100.31	6 20
76-77	10,707	1,163	108.62	5 84
77-78	9,544	1,123	117.65	5 49
78-79	8,421	1,073	127.44	5 16
79-80	7,348	1,014	138 06	4 84
80-81	6,334	947	149 55	4 53
81-82	5,387	873	161.98	4 24
82-83	4,514	792	175 42	3 96
83-84	3,722	707	189.92	3.70
84-85	3,015	620	205.56	3.45
85-86	2,395	533	222.40	3.21
86-87	1,862	448	240.54	2.99
87-88	1,414	368	260.05	2.77
88-89	1,046	294	281.01	2.57
89-90	752	228	303 53	2 38
90 91	524	172	327 68	2 20
91-92	352	124	353 58	2 03
92-93	228	87	381.33	1.87
93-94	141	58	411.05	1.72
94-95	83	37	442.83	1.57
95-96	46	22	476.82	1.43
96-97	24	12	513.14	1 29
97-98	12	7	551 92	1.17
98-99	5	3	593 31	1.10
99-100	2	1	637.45	1.02
100-101	1	1	684 51	0.51

TABLE 7.—*Life table for native-born, both sexes (1920), in the City of Manila.*

x to x+1, age interval, period of lifetime between two exact ages.	Of 100,000 persons (both sexes) born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginning of age interval.	o ex, expectation of life; average length of life remaining to each one alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
0–1	100,000	21,538	215.38	34.25
1–2	78,462	6,701	85.40	42.51
2–3	71,761	3,297	45.94	45.44
3–4	68,464	1,894	27.66	46.60
4–5	66,570	1,315	19.76	46.91
5–6	65,255	572	8.77	46.85
6–7	64,683	508	7.85	46.26
7–8	64,175	458	7.13	45.62
8–9	63,717	421	6.61	44.94
9–10	63,296	396	6.25	44.24
10–11	62,900	380	6.04	43.51
11–12	62,520	373	5.96	42.78
12–13	62,147	372	5.99	42.03
13–14	61,775	378	6.12	41.28
14–15	61,397	389	6.34	40.53
15–16	61,008	403	6.61	39.79
16–17	60,605	421	6.94	39.05
17–18	60,184	440	7.31	38 32
18–19	59,744	459	7.69	37 59
19–20	59,285	480	8.09	36 88
20–21	58,805	514	8.74	36.18
21–22	58,291	518	8.88	35.49
22–23	57,773	540	9.34	34.81
23–24	57,233	558	9.75	34.13
24–25	56,675	574	10.12	33.46
25–26	56,101	587	10.46	32.80
26–27	55,514	633	11.40	32.14
27–28	54,881	650	11.84	31.51
28–29	54,231	665	12.26	30.88
29–30	53,566	679	12.67	30.25
30–31	52,887	691	13.06	29.64
31–32	52,196	702	13.45	29.02
32–33	51,494	712	13 82	28.41
33–34	50,782	721	14 19	27.80
34–35	50,061	728	14 55	27 20
35–36	49,333	736	14 91	26.59
36–37	48,597	742	15 27	25.98
37–38	47,855	748	15.63	25.38
38–39	47,107	754	16.00	24.75
39–40	46,353	760	16.39	24.17
40–41	45,593	766	16.79	23.56
41–42	44,827	771	17.21	22.96
42–43	44,056	778	17.67	22.35

TABLE 7.—*Life table for native-born, both sexes (1920), in the City of Manila*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	Of 100,000 persons (both sexes) born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginning of age interval.	o ex, expectation of life; average length of life remaining to each one alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
43–44	43,278	785	18.15	21.74
44–45	42,493	793	18.67	21.14
45–46	41,700	802	19.24	20.53
46–47	40,898	812	19 86	19.92
47–48	40,086	824	20.55	19.32
48–49	39,262	836	21.30	18 71
49–50	38,426	851	22.14	18 11
50–51	37,575	866	23.06	17.51
51–52	36,709	884	24 09	16.91
52–53	35,825	904	25.23	16 31
53–54	34,921	925	26.50	15.72
54–55	33,996	948	27.90	15.13
55–56	33,048	974	29.46	14.55
56–57	32,074	1,000	31.19	13.98
57–58	31,074	1,029	33.10	13.42
58–59	30,045	1,058	35.22	12.86
59–60	28,987	1,088	37.55	12 31
60–61	27,899	1,120	40.13	11.77
61–62	26,779	1,151	42.97	11.24
62–63	25,628	1,181	46.09	10.72
63–64	24,447	1,211	49.53	10.22
64–65	23,236	1,238	53.30	9.72
65–66	21,998	1,263	57.43	9.24
66–67	20,735	1,284	61.94	8.78
67–68	19,451	1,301	66.88	8.32
68–69	18,150	1,312	72.28	7.88
69–70	16,838	1,316	78.15	7.46
70–71	15,522	1,312	84.55	7.05
71–72	14,210	1,300	91.51	6.65
72–73	12,910	1,279	99.08	6.27
73–74	11,631	1,248	107.29	5.91
74–75	10,383	1,206	116.18	5.56
75–76	9,177	1,155	125.81	5.22
76–77	8,022	1,093	136.24	4.90
77–78	6,929	1,022	147.50	4.59
78–79	5,907	943	159.65	4.30
79–80	4,964	858	172.76	4.02
80–81	4,106	767	186.90	3.76
81 82	3,339	675	202.11	3.51
82–83	2,664	582	218.47	3.27
83–84	2,082	491	236.07	3.05
84–85	1,591	406	254.96	2.84
85–86	1,185	326	275.23	2.63
86–87	859	255	296.98	2.44
87–88	604	193	320.28	2.26
88–89	411	142	345.23	2.09

TABLE 7.—*Life table for native-born, both sexes (1920), in the City of Manila*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	Of 100,000 persons (both sexes) born alive.		1,000 qx, rate of mortality per thousand; number dying in age interval among 1,000 alive at beginning of age interval.	o ex, expectation of life; average length of life remaining to each one alive at beginning of age interval.
	lx, number alive at the beginning of age interval.	dx, number dying in age interval.		
			Annual rate.	*Age in years.*
89–90	269	100	371.94	1.93
90–91	169	68	400.49	1.78
91–92	101	44	431.01	1.63
92–93	57	26	463.61	1.51
93–94	31	15	498.40	1.35
94–95	16	9	535.52	1.19
95–96	7	4	575.09	1.14
96–97	3	2	617.26	0.83
97–98	1	1	662.18	0.27

TABLE 8.—*Life table for native-born in the City of Manila and of Filipinos, Japanese, Chinese, and Hawaiians in Hawaii, both sexes (1920), and colored people, males and females, in the original Registration States, United States, for the year 1910.*

x to x+1, age interval, period of lifetime between two exact ages.	o ex, expectation of life, both sexes, in years.						
	Manila.	In Hawaii.				Colored people in the original Registration States, 1910.	
		Filipinos.	Japanese.	Chinese.	Hawaiians.	Males.	Females.
0–1	34.25	36.93	51.88	52.28	29.00	34.05	37.67
1–2	42.51	49.02	56.22	56.37	36.60	42.53	45.15
2–3	45.44	50.80	56.54	56.25	37.34	44.55	46.95
3–4	46.60	50.98	56.11	55.74	37.14	45.01	47.12
4–5	46.91	50.73	55.56	55.17	36.71	44.78	46.87
5–6	46.85	50.17	54.97	54.55	36.13	44.25	46.42
6–7	46.26	49.56	54.28	53.84	35.45	43.62	45 81
7–8	45.62	48.84	53.51	53.08	34.73	42.94	45.13
8–9	44.94	48.06	52.69	52.27	33.99	42.20	44 39
9–10	44.24	47.25	51.84	51.43	33.25	41.44	43 62
10–11	43.51	46.25	50.97	50.57	32.52	40.65	42 84
11–12	42.78	45.59	50.10	49.71	31.81	39.85	42.06
12–13	42.03	44.77	49.23	48.85	31.13	39.05	41.29
13–14	41.28	43.96	48.37	47.96	30.49	38.27	40.56
14–15	40.53	43.17	47.54	47.15	29.88	37.51	39.85
15–16	39.79	42.41	46.74	46.32	29.31	36.77	39.18
16–17	39.05	41.69	45.96	45.47	28.77	36.05	38.55
17–18	38 32	40.99	45.21	44.67	28.27	35.37	37.95
18–19	37.59	40.31	44.49	43.91	27.81	34.71	37.35
19–20	36.88	39.67	43.79	43.16	27.88	34 08	36.75

TABLE 8.—*Life table for native-born in the City of Manila and of Filipinos, Japanese, Chinese, and Hawaiians in Hawaii, both sexes (1920), and colored people, males and females, in the original Registration States, United States, for the year 1910*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	e_x, expectation of life, both sexes, in years.						
	Manila.	In Hawaii.				Colored people in the original Registration States, 1910.	
		Filipinos.	Japanese.	Chinese.	Hawaiians.	Males.	Females.
20–21	36.18	39.04	43.12	42.44	26.97	33.46	36.14
21–22	35.49	38.43	42.47	41.73	26.58	32.86	35.53
22–23	34.81	37.82	41.82	41.03	26.20	32.26	34.90
23–24	34.13	37.21	41.17	40.35	25.81	31.67	34.27
24–25	33.46	36 60	40 52	39.48	25.42	31.06	33.63
25–26	32.80	35.98	39.36	39.00	25.03	30.44	32.97
26–27	32.14	35.36	39.21	38.33	24.64	29.81	32.29
27–28	31.51	34.73	38.55	37.67	24.25	29.18	31.61
28–29	30.88	34.11	37.89	37.01	23.86	28.55	30.94
29–30	30.25	33.48	37.23	36.35	23.47	27.94	30.27
30–31	29.64	32.86	36.57	35.70	23.07	27.33	29.61
31–32	29.02	32.23	35.91	35.05	22.68	26.74	28.96
32–33	28.41	31.61	35.23	34.39	22.28	26.16	28.33
33–34	27.80	30.98	34.56	33.74	21.89	25.58	27.70
34–35	27.20	30.35	33.88	33.08	21.49	25.00	27.07
35–36	26.59	29.73	33.20	32 43	21.09	24.42	26.44
36–37	25.98	29.09	32.52	31.75	20.68	23.84	25.81
37–38	25.38	28.46	31.83	31.06	20.27	23.26	25.18
38–39	24.75	27.83	31.14	30.41	19.86	22.69	24.56
39–40	24.17	27.19	30.45	29.74	19.47	22.12	23.94
40–41	23 56	26.56	29.76	29.06	19.05	21.57	23.34
41–42	22 96	25.92	29.06	28.37	18.63	21.02	22.75
42–43	22.35	25.28	28.36	27.68	18.21	20.48	22.16
43–44	21.74	24.64	27.67	26.99	17.79	19.94	21.58
44–45	21.14	24.00	26.96	26.29	17.37	19.39	21.00
45–46	20.53	23.36	25.56	25.59	16.93	18.85	20.43
46–47	19.92	22.72	25.56	24.88	16.51	18.30	19.86
47–48	19.32	22.08	24.86	24.17	16.16	17.75	19.30
48–49	18.71	21.44	24.17	23.46	15.65	17.22	18.75
49–50	18.11	20.80	23.47	22.75	15.21	16.71	18.20
50–51	17.51	20.16	22.77	22.03	14.78	16.21	17.65
51–52	16.91	19.53	22 08	21.32	14.35	15.72	17.10
52–53	16.31	18.90	21.40	20.61	13.91	15.23	16.55
53–54	15.72	18.27	21.71	19.90	13.48	14.75	16.01
54–55	15.13	17.65	20.04	19.19	13.05	14.28	15.48
55–56	14.55	17.04	19.37	18.49	12.62	13.82	14.98
56–57	13.98	16.43	18.71	17.79	12.20	13.36	14.50
57–58	13.42	15.83	18.06	17.10	11.77	12.93	14.05
58–59	12.86	15.23	17.41	16.41	11.35	12.50	13.62
59–60	12.31	14.64	16.78	15.73	10.94	12.08	13.20

TABLE 8.—*Life table for native-born in the City of Manila and of Filipinos, Japanese, Chinese, and Hawaiians in Hawaii, both sexes (1920), and colored people, males and females, in the original Registration States, United States, for the year 1910*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	e_x, expectation of life, both sexes, in years.						
	Manila.	In Hawaii.				Colored people in the original Registration States, 1910.	
		Filipinos.	Japanese.	Chinese.	Hawaiians.	Males.	Females.
60–61	11.77	14 07	16.15	15.07	10 53	11.67	12.78
61–62	11.24	13.50	15.54	14.41	10.12	11.27	12.37
62–63	10.72	12.94	14.93	13 77	9.72	10.88	11.96
63–64	10.22	12.39	14.32	13 14	9.33	10.49	11.56
64–65	9.72	11.86	13.71	12 52	8.94	10.11	11.18
65–66	9.24	11.33	13.10	11.97	8.56	9.74	10.82
66–67	8.78	10.82	12.50	11.33	8.19	9.38	10.49
67–68	8.32	10.32	11.91	10.75	7.83	9.02	10 17
68–69	7.88	9.84	11.32	10.20	7.74	8.67	9.86
69–70	7.46	9.37	10.74	9.66	7.12	8.33	9.54
70–71	7.05	8.91	10.17	9.14	6.79	8.00	9.22
71–72	6.65	8.46	9.62	8.63	6.46	7.69	8.89
72–73	6.27	8.03	9.06	8.15	6.14	7.39	8.55
73–74	5.91	7.62	8.55	7.68	5.83	7.11	8.21
74–75	5.56	7.22	8.05	7.23	5.53	6.84	7.88
75–76	5.22	6.83	7.56	6.80	5.24	6.58	7.55
76–77	4.90	6.46	7.09	6.39	4.96	6.36	7.22
77–78	4.59	6.10	6.64	6.00	4.69	6.15	6 91
78–79	4.30	5.76	6.21	5.62	4.43	5.96	6.61
79–80	4.02	5.43	5.81	5.27	4.17	5.76	6.32
80–81	3.76	5.17	5.44	4.93	3.93	5.53	6.05
81–82	3.51	4.82	5.05	4.60	3.69	5.29	5.81
82–83	3.27	4.53	4.71	4.30	3.47	5.06	5.59
83–84	3.05	4.25	4.38	4.01	3.30	4.84	5.40
84–85	2.84	3.99	4.07	3.73	3.10	4.64	5.23
85–86	2.63	3.74	3.78	3.47	2.91	4.48	5.09
86–87	2.44	3.50	3.51	3.23	2.72	4.86	4.97
87–88	2.26	3.27	3.25	3.00	2.55	4.26	4.86
88–89	2.09	3.05	3.03	2.78	2.38	4.18	4.76
89–90	1.93	2.84	2.79	2.57	2.22	4 10	4.64
90–91	1.78	2.64	2.59	2.38	2.06	4.01	4.50
91–92	1.63	2.44	2.39	2 20	1.91	3.89	4.34
92–93	1.51	2.24	2.21	2.03	1.77	3.75	4.14
93–94	1.35	2.17	2.04	1.87	1.62	3.57	3.92
94–95	1.91	2.02	1.89	1.70	1.45	3.37	3.69
95–96	1.14	1.87	1.74	1.58	1.32	3.15	3.45
96–97	0.83	1.74	1.60	1.45	1.24	2 93	3.22
97–98	0.27	1.61	1.48	1.33	1.04	2.72	2.99

TABLE 8.—*Life table for native-born in the City of Manila and of Filipinos, Japanese, Chinese, and Hawaiians in Hawaii, both sexes (1920), and colored people, males and females, in the original Registration States, United States, for the year 1910*—Continued.

x to x+1, age interval, period of lifetime between two exact ages.	e_x, expectation of life, both sexes, in years.						
	Manila.	In Hawaii.				Colored people in the original Registration States, 1910.	
		Filipinos.	Japanese.	Chinese.	Hawaiians.	Males.	Females.
98–99	.....	1.49	1 36	1.22	.70	2.51	2.78
99–100	.....	1 38	1.24	1.10	.....	2.32	2.58
100–101	.....	1.29	1.13	1.00	.....	2.14	2.39
101–102	.....	1.22	1.02	.65	.....	1.97	2.21
102–103	.....	1.20	.89	.....	.....	1.81	2.05
103–104	.....	.13	.65	.....	.....	1.66	1.89
104–105	.....	.....	.....	.....	.....	1.53	1.74
105–106	.....	.....	.....	.....	.....	1.40	1.59
106–107	.....	.....	.....	.....	.....	1.27	1.45
107–108	.....	.....	.....	.....	.....	1.16	1.32
108–109	.....	.....	.....	.....	.....	.....	1.20
109–110	.....	.....	.....	.....	.....	.....	1.08

ACKNOWLEDGMENT

I am indebted to Maj. Paul R. Hawley, of the Medical Corps, United States Army, for valuable suggestions and assistance in the preparation of this paper; to Dr. Jose Guidote, chief of the division of vital statistics of the Philippine Health Service, who furnished the mortality data; to Sanitary Inspector Basilio Martinez, who prepared the charts accompanying the paper; and to Sanitary Inspector Amado Castillo and Clerk Victorio Yabot, for their assistance.

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ILLUSTRATIONS

TEXT FIGURES

THERMAL AND PHOTOCHEMICAL DECOMPOSITION OF CARYOPHYLLENE NITROSITE

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and

FARRINGTON DANIELS

Of the Department of Chemistry, University of Wisconsin

FOUR TEXT FIGURES

Few photochemical reactions are known which are brought about by red light, although many are known which are responsive to blue light or ultra-violet light. The red-sensitive reactions are particularly favorable for study, because the intensity of red light from an ordinary lamp is much greater than the intensity of blue light, and quantitative experiments with monochromatic light are facilitated. Furthermore, according to certain hypotheses connecting photochemical reactions with thermal reactions, infra red or red light should be photochemically active, and a reaction brought about by red light becomes especially valuable if it can be brought about also by thermal means.

Prof. Edward Kremers discovered that caryophyllene nitrosite is decomposed by red light and it was the purpose of this research to study the reactions quantitatively with new and improved photochemical apparatus and to determine if the reaction can be brought about also by ordinary heating. The quantitative study of the decomposition rate at approximately 80, 100, and 110° C. is described in this paper, and it is planned to study the photochemical decomposition very shortly.

Caryophyllene nitrosite was first made by Schreiner and James [1] by following the method of Chapman [2] used in preparing humulene nitrosite. Later Schreiner and Kremers [3] prepared this compound and observed the action of sunlight on the sub-

[1] Pharm. Arch. 1 (1898) 213.
[2] Journ. Chem. Soc. 67 (1895) 782.
[3] Pharm. Arch. 2 (1899) 14.

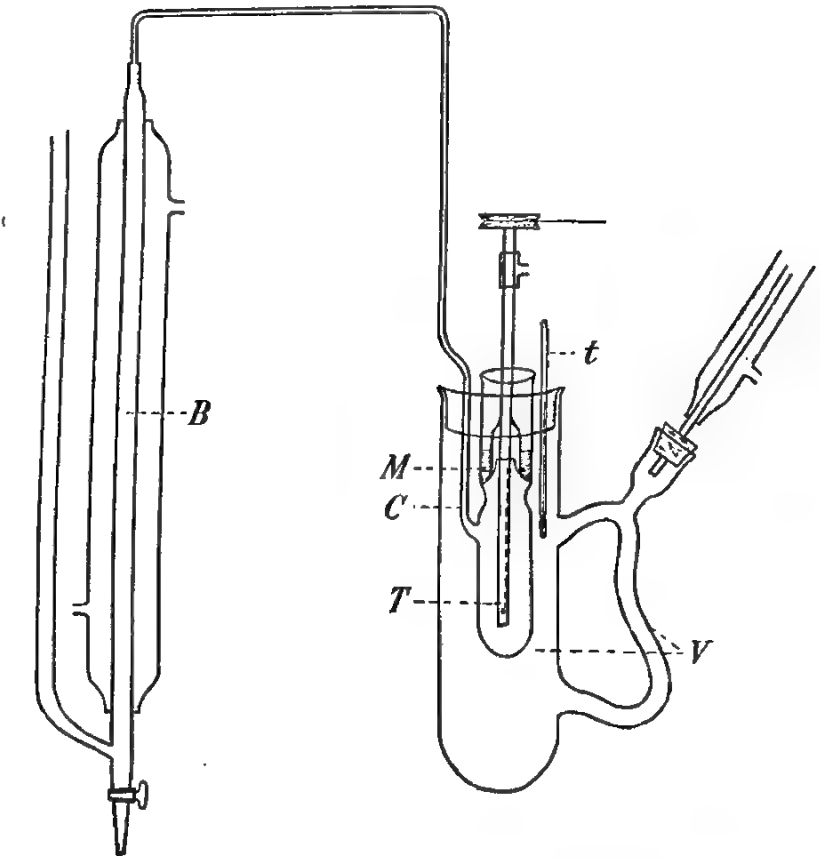

FIG. 1. Apparatus for the thermal decomposition of caryophyllene nitrosite.

stance dissolved in benzene solution. It was observed that when the perfectly blue solution in benzene was exposed to sunlight the solution almost immediately began to give off a gas, while small feltlike and perfectly white crystals began to separate. The liberated gas was considered to be nitrogen. By using a nitrometer the compound dissolved in benzene solution was found to evolve about 28.94 per cent of total nitrogen, whereas 10.19 per cent of the same gas was liberated from the alcoholic solution. A few years ago, Professor Kremers and some of his students [4] studied further the action of sunlight on caryophyllene nitrosite solution and its mother liquid. Quantitative measurements of the gas were made.

[4] Manuscripts.

DESCRIPTION OF APPARATUS

The apparatus used in the thermal decomposition experiments was that shown in fig. 1. The solution was placed in a tube *T* provided with a mercury seal *M*. The side tube *C* with very small diameter is connected with small glass tubing (almost capillary) which is connected with a 50-cubic-centimeter burette *B*, jacketed in a condenser in which the gas evolved was collected. The condenser was used to keep the temperature of the water surrounding the burette practically the same. The tube *T* containing the solution was jacketed in a vapor thermostat *V*, which is connected with a small condenser. The vapor thermostat contained the liquid the boiling point of which approached the temperature at which it was desired that the decomposition should take place. A thermometer *t*, accurate to 0.1 °, was inserted through the cork in order to observe the temperature at which the decomposition was taking place. All connections were made gas tight.

MATERIAL

The caryophyllene nitrosite used in this work was kindly furnished by Professor Kremers of the Department of Pharmacy. It was prepared several years ago by him and his students, according to the method of Schreiner and Kremers.[5] In spite of having been allowed to stand for a long time in an open container, the substance still possessed the fine needlelike bright blue crystalline form, melting at 115° C. Only few of the exposed crystals on the surface had undergone slight change in color, from bright blue to slightly yellowish brown. These crystals melted at 110° C. In our experiments care was always taken to use the bright blue crystals, melting at 115° C. They readily dissolve in alcohol, benzene, and carbon tetrachloride, giving a blue solution, while if dissolved in nitrobenzene the color is somewhat greenish. On exposure to sunlight the solution is decolorized and an insoluble white compound is formed in alcohol, benzene, and carbon tetrachloride.[6] In nitrobenzene, the solution changes from greenish blue to brownish without the formation of a white product of decomposition.

[5] Pharm. Arch. 2 (1899) 14.

[6] Cf. O. Schreiner and E. Kremers, Pharm. Arch. 2 (1899) 273; Ibid, 6 (1903) 130–131; also E. Deussen, Ann. 388 (1912) 139.

The following solvents were employed:

Nitrobenzene.—The nitrobenzene used was that manufactured by Merck and Company.

Paraffine.—The paraffine was obtained from the Standard Oil Company of Indiana.

Limonene.—The limonene was kindly furnished by Dr. Nellie Wakeman, of the Laboratory of Plant Chemistry, University of Wisconsin, who rectified it from commercial orange oil.

EXPERIMENTAL PROCEDURE

A sufficient amount of the desired liquid was poured into the vapor thermostat. Twenty cubic centimeters of the solvent were pipetted into the tube and the liquid in the thermostat was heated to boiling by means of an electric heater. The boiling was allowed to continue for thirty minutes. Then 1 gram of the substance, made into a pellet, was dropped into the tube and the solution was constantly stirred by means of an electric stirrer.

The rate of decomposition was measured by taking the volume readings at measured intervals. The burette in which the gas was collected was filled in every case with nitrobenzene and the level in the burette and that in the side tube were made to agree at every reading of the volume of the gas evolved. The final observation was made when no further increase in volume was noticed. To find out the length of time that would be required to obtain the final volume, the apparatus was allowed to remain undisturbed for forty-eight hours. During this period the readings were taken at intervals of twelve hours. The final volume in this case differs only slightly from the reading which was taken after two hours' standing.

The solvents used were nitrobenzene, melted paraffine, and rectified limonene. The liquids employed in the thermostat were carbon tetrachloride (76° C.), distilled water (100° C.), and toluene, chemically pure (110° C.). Different solvents were used to see whether or not the decomposition is affected by the nature of the solvent. The solvent was always heated for thirty minutes previous to the dropping of the substance in order to avoid the effect of unequal temperature at the beginning of the experiment.

CALCULATIONS

Figure 2 shows the curves obtained by plotting the volume of the gas evolved during the thermal decomposition of caryophyl-

lene nitrosite dissolved in nitrobenzene. The decomposition at the boiling point of carbon tetrachloride is represented by curve A. Curve B shows the decomposition at 100° C. (water), and curve C shows the decomposition at 110° C. (toluene).

Figure 3 represents the graphic grouping of the results obtained from the decomposition of caryophyllene nitrosite in limonene solution. Curve A represents the results at the boiling point of carbon tetrachloride, curve B at 100° C., and curve C at 110° C.

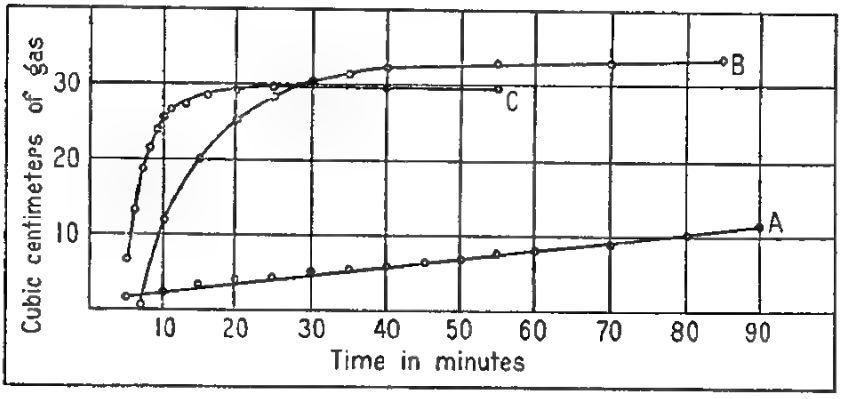

FIG. 2. Thermal decomposition of caryophyllene nitrosite dissolved in nitrobenzene.

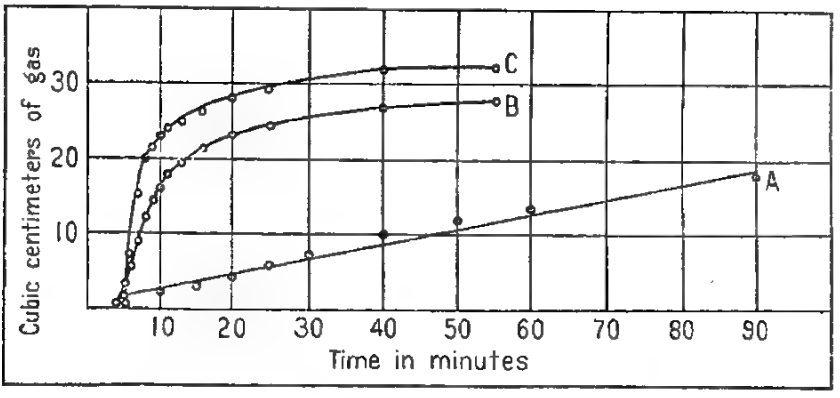

FIG. 3. Thermal decomposition of caryophyllene nitrosite dissolved in limonene.

Figure 4 gives the curves obtained when the caryophyllene nitrosite was decomposed in melted paraffine. The results at 100° C. (water) are represented by curve A, while curve B shows the decomposition at 110° C. (toluene). In this case the

paraffine was first melted and then the caryophyllene nitrosite pellet was dropped into it. The decomposition at lower temperature was not studied.

Tables 1, 2, and 3 give the decomposition of caryophyllene nitrosite carried out under different conditions. The first section gives the time readings expressed in seconds; the second gives the volume readings in cubic centimeters of the gas evolved at each interval; the third gives the difference between the final volume V and the volume at any time V_t, and the fourth gives the velocity constants. The columns give the respective results obtained at the boiling points of the liquids used in the vapor thermostat; namely, carbon tetrachloride, water, and toluene. The reaction velocity constants were calculated directly from the data given in the columns, with the aid of the following formula:

$$K = \frac{2.302}{t_2 - t_1} \log. \frac{V\infty - V_{t_1}}{V\infty - V_{t_2}}$$

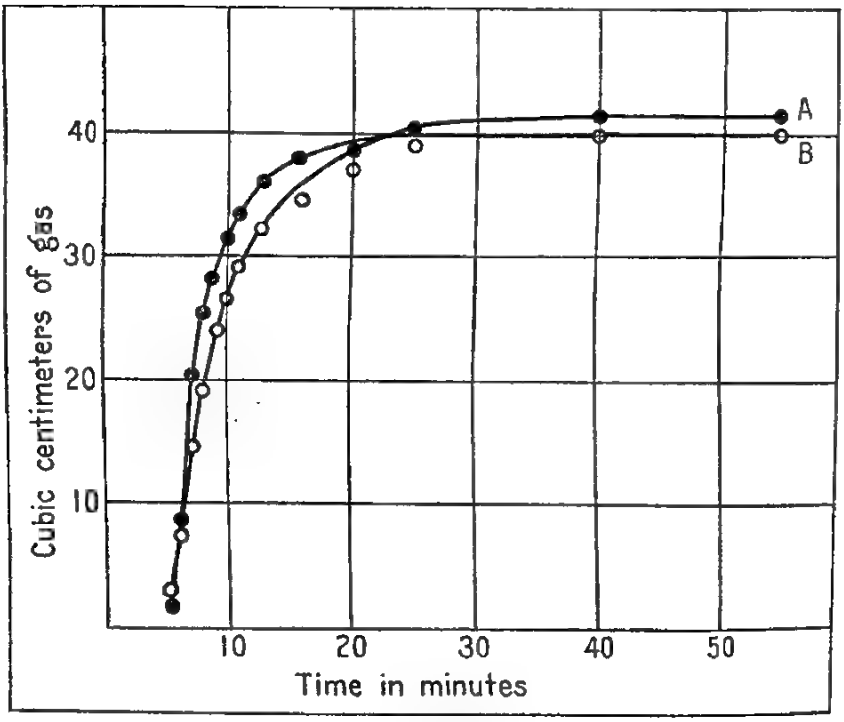

FIG. 4. Thermal decomposition of caryophyllene nitrosite dissolved in paraffine.

TABLE 1.—*Thermal decomposition of caryophyllene nitrosite in nitrobenzene solution.*

Time in seconds.			Volume of gas evolved.			Difference between final volume and volume at any time.			Velocity constant		
Carbon tetrachloride. t	Water. t	Toluene. t	Carbon tetrachloride. $V_0 = 1.8$	Water. $V_0 = 11.2$	Toluene. $V_0 = 5.5$	Carbon tetrachloride. $V_\infty = 25.2$	Water. $V_\infty = 41.7$	Toluene. $V_\infty = 29.9$	Carbon tetrachloride. $K \times 10^{-4}$	Water. $K \times 10^{-4}$	Toluene. $K \times 10^{-3}$
			cc.	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*			
0	0	0	1.8	11.2	5.5						
300	300	60	2.4	20.65	13.8	23.40	21.05	24.4	0.85	3.12	6.92
600	600	120	3.2	25.20	18.8	22.80	16.50	16.1	1.17	6.91	6.20
900	900	180	3.8	28.3	21.8	22.0	13.40	11.1	0.91	5.37	5.24
1200	1200	240	4.3	30.3	24.0	21.4	11.50	8.10	0.75	3.19	5.26
1500	1500	300	4.8	31.35	25.8	20.09	10.35	5.9	0.94	2.52	1.38
1800	1800	480	5.4	32.1	27.45	20.04	9.6	4.6	0.98	3.68	1.50
2100	2700	900	5.9	33.1	29.00	19.80	8.6	2.45	0.97	1.99	1.67
2400	4500	1200	6.5	34.6	29.5	19.3	8.1	0.9	0.94	1.69	0.90
2700		2100	7.0		29.7	18.70		0.4	0.88		0.77
3000			7.5			17.70			0.91		
3300			8.1			17.1			.82		
5400			12.8			12.4			1.94		
8760			17.8			7.4			1.37		

TABLE 2.—*Thermal decomposition of caryophyllene nitrosite in limonene solution.*

Time in seconds.			Volume of gas evolved.			Difference between final volume and volume at any time.			Velocity constant.		
Carbon tetrachloride. t	Water. t	Toluene. t	Carbon tetrachloride. $V_o = 1.8$	Water. $V_o = 3.1$	Toluene. $V_o = 0.2$	Carbon tetrachloride. $V_\infty = 21.6$	Water. $V_\infty = 19.9$	Toluene. $V_\infty = 32.3$	Carbon tetrachloride. $K \times 10^{-4}$	Water. $K \times 10^{-4}$	Toluene. $K \times 10^{-4}$
			cc.	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*			
0	0	0	1.8	3.1	0.2						
300	60	60	2.5	5.9	7.2	19.8	26.8	32.10	1.00	1.84	4.08
600	120	120	3.3	9.4	16.2	19.2	24.0	25.1	1.60	2.63	7.33
900	180	180	4.7	12.4	20.0	18.3	20.5	16.10	2.62	2.64	4.46
1200	240	240	6.0	14.8	21.80	16.9	17.5	12.30	2.62	2.46	2.62
1500	300	300	7.4	16.5	22.9	15.6	15.1	9.40	1.57	2.00	1.82
2100	360	360	10.0	17.80	23.8	14.2	13.4	8.50	3.35	1.70	1.66
2700	480	420	12.0	19.70	25.2	11.1	12.1	7.10	3.14	2.28	1.44
3300	660	540	13.7	21.70	26.60	9.60	8.2	5.70	2.15	0.94	0.91
4200	900	620	15.5	23.35	28.00	7.9	6.55	4.30	1.43	0.93	0.93
6000	1200	----------	18.10	24.60	----------	6.1	5.30	----------	1.54	0.70	----------
9600	----------	----------	20.4	----------	----------	3.5	----------	----------	2.98	----------	----------

TABLE 3.—*Thermal decomposition of caryophyllene nitrosite dissolved in melted paraffine.*

Time in seconds.		Volume of gas evolved.		Difference between final volume and volume at any time.		Velocity constant.	
Water. t	Toluene. t	Water. $V_o = 3.0$	Toluene. $V_o = 2.0$	Water. $V_\infty = 41.6$	Toluene. $V_\infty = 40$	Water. $K \times 10^{-3}$	Toluene. $K \times 10^{-3}$
		cc.	cc.	cc.	cc.		
0	0	3.0	2.0				
60	60	8.8	8.0	38.60	32	2.71	8.25
120	120	14 7	20.50	32.80	19 5	3.30	4.91
180	180	19.60	25.50	26.90	14 00	3 34	3.57
240	240	24.0	28.3	22.00	11 70	3.71	5.22
300	300	26.90	31.5	17.60	8.50	2.99	4.89
360	360	29.20	33.7	14.70	6.30	1.41	3.99
480		32.30	36.10	12 40		0.69	3.71
660		34.80		9.30		3.84	

TABLE 4.—*Velocity constants.*

Solvents.	Nitrobenzene.			Limonene.
Liquids in vapor thermostats.	Carbon tetrachloride.	Water.	Toluene.	Carbon tetrachloride.
Maximum	1.94×10^{-4}	8.12×10^{-4}	6.92×10^{-3}	3.35×10^{-4}
Minimum	0.75×10^{-4}	1.69×10^{-4}	0.77×10^{-3}	1.00×10^{-4}
Mean	1.03×10^{-4}	4.30×10^{-4}	3.31×10^{-3}	2.18×10^{-4}

Solvents.	Limonene.		Paraffine.	
Liquids in vapor thermostats.	Water.	Toluene.	Water.	Toluene.
Maximum	2.64×10^{-3}	7.33×10^{-3}	3.84×10^{-3}	8.25×10^{-3}
Minimum	0.70×10^{-3}	0.91×10^{-3}	0.69×10^{-3}	3.71×10^{-3}
Mean	1.81×10^{-3}	2.80×10^{-3}	2.64×10^{-3}	4.91×10^{-3}

RESULTS

A glance at the columns of the velocity constants reveals considerable variation in the figures; Table 4 gives the maximum, minimum, and mean values obtained in each case. These values were calculated from experiments carried in duplicate which gave figures agreeing closely within permissible error. The figures at low temperature seem to agree more closely than the values calculated from the data obtained at the boiling point of carbon tetrachloride, less than 100 and 110° C. Apparently, the decomposition of caryophyllene nitrosite is not a simple

reaction, but is a more or less complex one. Semmler and Jakubowicz [7] observed that most of the sesquiterpenes are decomposed when heated for several hours at higher temperature. Although the temperature at which Semmler and Jakubowicz [7] decomposed the sesquiterpenes was 330° C., it is possible that secondary stages of decomposition are also involved in the heating of caryophyllene nitrosite, thus rendering the reaction complex.

Considering, however, the mean velocity constants obtained from each of our experiments, the following facts are apparent:

1. The velocity of the decomposition is influenced by the nature of the solvent, which is in agreement with the observation of Menshtkin.[8] Thus, comparing the reaction velocity constants in melted paraffine and in limonene at the same temperature, 110° C., the velocity is shown to differ in the two cases.

2. The compound behaves rather abnormally with regard to the relation between the velocity of the reaction and the temperature. Thus, in case of the solution in nitrobenzene, for a difference of about 24° C., the velocity was increased four times, whereas in the case of water and of toluene, the velocity was increased seven times. The behavior of the solution in limonene was different from the first one, since the velocity was about nine times greater from the boiling point of carbon tetrachloride and of water, whereas it increased twice its velocity at from 100 to 110° C.

In melted paraffine the velocity was doubled at from 100 to 110° C. From these results it appears that, while the increase in the velocity was abnormal in nitrobenzene, yet it seemed to follow the general rule (velocity of the reaction is doubled at an increase of 10° C.) when decomposed at from 100 to 110° C. in solutions of limonene and of paraffine.

Although the experimental data show that reaction is rather complex, and suggest that two or more reactions are taking place simultaneously, it is believed that the temperature coefficient of the reaction rate may permit a fairly close approximation of the energy required to bring about the reaction, and that this energy may be checked with the energy required to bring about the photochemical reaction.

We are indebted to Prof. Edward Kremers who indicated the behavior of caryophyllene nitrosite toward sunlight and who suggested that this study be made.

[7] Berichte 47 (1914) 2252–2259. [8] Zeit. Phys. Chem. 6 (1890) 41.

ILLUSTRATIONS

TEXT FIGURES

ESTERS OF ALPHA LINOLIC ACID TETRABROMIDE (METHYL, ETHYL, PROPYL, ISOPROPYL, AND ALLYL) FROM LUMBANG OIL

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and

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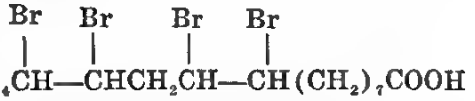
Professor of Chemistry, University of the Philippines

Linolenic and linolic glycerides are the important constituents of vegetable drying oils, since these are the substances that absorb oxygen from the air and cause the oil to dry. Philippine lumbang oil [1] consists almost entirely of glycerides of the unsaturated acids linolenic, linolic, and oleic.[2] It is a drying oil and is used in making paints, varnishes, and similar products.[3] When the mixed acids obtained from the glycerides of lumbang oil are brominated there is obtained a mixture of bromo derivatives of the unsaturated acids linolenic, linolic, and oleic. A recent investigation [4] indicated that four different linolic tetrabromides can be separated from this mixture of bromo derivatives. Although the free linolic acids oxidize readily, the linolic tetrabromides are very stable compounds and consequently are important substances in the chemistry of vegetable drying oils. A fair yield of crystallized alpha linolic tetrabromide can be obtained from lumbang oil.



alpha linolic tetrabromide

Various salts [5] of this substance have been made and the solubility of these salts in different solvents has been determined.

[1] West, A. P., and W. H. Brown, Bull. Philip. Bur. Forestry 20 (1920) 121.

[2] West, A. P., and Z. Montes, Philip. Journ. Sci. 18 (1921) 619.

[3] West, A. P., and F. L. Smith, Bull. Philip. Bur. Forestry 24 (1923).

[4] Santiago, S., and A. P. West, Philip. Journ. Sci. 32 (1927) 41.

[5] Oreta, A. T., and A. P. West, Philip. Journ. Sci. 33 (1927) 169; Jovellanos, C. M., and A. P. West, Philip. Journ. Sci. 33 (1927) 349.

In the present investigation a few esters of alpha linolic tetrabromide have been prepared. The esters did not give a very sharp melting point. In this respect they appear to resemble salts of long-chain acids since, according to the literature,[6] many of these salts do not give a sharp melting point.

EXPERIMENTAL PROCEDURE

Preparation of alpha linolic tetrabromide.—Philippine lumbang oil was used as the material for preparing a supply of alpha linolic tetrabromide. The lumbang oil was pressed from seeds of good quality and filtered first through glass wool and then through filter paper.

The alpha linolic tetrabromide was prepared from lumbang oil, in accordance with the procedure adopted by Santiago and West[7] in a recent investigation of lumbang compounds. The lumbang oil was saponified with aldehyde-free alcoholic potassium hydroxide.[8] The mixed potassium soaps thus obtained were converted into the mixed acids. The mixed acids were brominated in ether solution, according to the procedure used by Imperial and West[9] in preparing linolenic hexabromide. The ether solution of mixed acids was stirred mechanically by means of a hot-air motor and brominated at —10° C. The insoluble linolenic hexabromide was removed by filtering. The ethereal filtrate from the hexabromide was treated with sodium thiosulphate solution to remove the bromine, dehydrated with sodium sulphate, and distilled to eliminate the ether. The residue was treated with cold petroleum ether which precipitated a mixture of linolic tetrabromides. The crude solid tetrabromides were separated from the oily (gamma) tetrabromide and oily oleic dibromide by filtering. The crude crystalline tetrabromides were washed with petroleum ether, after which they were crystallized from ethyl alcohol. Two crops of impure alpha linolic tetrabromide (melting point, 110 to 113° C.) were obtained. The crude alpha tetrabromide was washed again with petroleum ether and crystallized once from gasoline and several times

[6] Beilstein's Handbuch der Organischen Chemie, Vierte Auflage, 2 (1920) 361, 369, 372, 374, 395, 396, 466, 473; Imperial, G. A., and A. P. West, Philip. Journ. Sci. 31 (1926) 441; Almoradie, P. R., and A. P. West, Philip. Journ. Sci. 33 (1927) 257; Oreta, A. T., and A. P. West, Philip. Journ. Sci. 33 (1927) 169.

[7] Philip. Journ. Sci. 32 (1926) 41.

[8] Dunlap, F. L., Journ. Am. Chem. Soc. 28 (1906) 397.

[9] Philip. Journ. Sci. 31 (1926) 44.

from ethyl alcohol. After this further purification the melting point was 112.3 to 114.3° C.

Esters of alpha linolic tetrabromide were prepared by first converting the tetrabromide into the acid chloride of alpha linolic acid tetrabromide. The acid chloride was then treated with various alcohols.

Methyl ester of alpha linolic tetrabromide.—Alpha linolic acid tetrabromide (40 grams) was placed in a flask and heated over a wire gauze until the acid was melted completely. Phosphorus trichloride (2.7 cubic centimeters) was poured into a dropping funnel and allowed to drop slowly into the melted tetrabromide. The mixture was then heated for about fifteen minutes, or until the reaction was apparently complete. The acid chloride was then poured off from the viscous phosphorus acid, filtered through glass wool, and the filtrate allowed to drop into a flask containing 20 cubic centimeters of methyl alcohol. The mixture of methyl alcohol and acid chloride was then heated (reflux) on a water bath for about four hours. When cooled in ice water the crude methyl ester separated out as an amorphous mass which had a slightly yellow color. The crude reaction product was then removed by filtering and crystallized four times from methyl alcohol. The purified ester was obtained as a white amorphous powder. The methyl ester melted at 56 to 60° C. The ester was found to be very soluble in the common organic solvents.

Analysis:

	Bromine. Per cent.
Calculated for $C_{19}H_{34}O_2Br_4$	52.09
Found	52.06

Ethyl ester of alpha linolic tetrabromide.—Forty grams of alpha linolic acid tetrabromide were treated with 2.7 cubic centimeters of phosphorus trichloride. The acid chloride thus obtained was filtered through glass wool into a flask containing 20 cubic centimeters of ethyl alcohol. The mixture of chloride and alcohol was heated (reflux) on a water bath for about two hours. The reaction product was then cooled in ice water and the excess of alcohol poured off from the crude ester. After crystallizing several times from methyl alcohol the ester was obtained as white sparkling crystals. The melting point was 58 to 60° C. The ester was very soluble in the usual organic solvents.

Analysis:

	Bromine. Per cent.
Calculated for $C_{20}H_{36}O_2Br_4$	50.93
Found	50.80

Propyl ester of alpha linolic tetrabromide.—Alpha linolic tetrabromide (40 grams) was treated with phosphorus trichloride (2.7 cubic centimeters). The acid chloride thus obtained was filtered and added to 25 cubic centimeters of normal propyl alcohol. The mixture was heated (reflux) over a wire gauze for about three hours; it was then cooled and the precipitated ester separated from the excess alcohol by filtering. The crude ester was crystallized several times from methyl alcohol. The glittering white crystals melted at 45 to 50° C. The ester was very soluble in the common organic solvents.

Analysis:

	Bromine. Per cent.
Calculated for $C_{21}H_{38}O_2Br_4$	49.82
Found	49.66

Isopropyl ester of alpha linolic tetrabromide.—Alpha linolic tetrabromide (15 grams) was treated with 0.93 cubic centimeter of phosphorus trichloride. The acid chloride was filtered through glass wool and added to 20 cubic centimeters of isopropyl alcohol. The mixture was heated (reflux) on a water bath for about four hours. The reaction product was then cooled in ice water and the excess of alcohol removed by filtering. The crude ester was crystallized several times from methyl alcohol. The melting point was 50 to 52° C. The ester was very soluble in the usual organic solvents.

Analysis:

	Bromine. Per cent.
Calculated for $C_{21}H_{38}O_2Br_4$	49.82
Found	49.53

Allyl ester of alpha linolic tetrabromide.—The method used for preparing this ester was quite similar to the procedure employed in making the isopropyl ester. Fifteen grams of alpha linolic tetrabromide were treated with 0.93 cubic centimeter of phosphorus trichloride. The acid chloride was filtered through glass wool and added to 15 cubic centimeters of allyl alcohol. The mixture was heated (reflux) over a wire gauze for about eight hours. When cooled in ice water the reaction product separated out as a brown precipitate which was some-

what sticky. The excess alcohol was poured off and the crude ester crystallized several times from methyl alcohol. After purification the ester was obtained as an amorphous mass which was still slightly yellow. The melting point was 72 to 80° C. The ester was very soluble in benzene, chloroform, ethyl benzoate, toluene, and xylene. When treated with acetone, ether, ethyl alcohol, ethyl acetate, propyl alcohol, and petroleum ether the ester formed turbid solutions and did not dissolve completely.

Analysis:

	Bromine. Per cent.
Calculated for $C_{21}H_{36}O_2Br_4$	49.98
Found	49.93

SUMMARY

A considerable quantity of alpha linolic acid tetrabromide (melting point, 112.3 to 114.3° C.) was made from lumbang oil.

The acid chloride of alpha linolic acid tetrabromide was prepared by treating alpha linolic acid tetrabromide with phosphorus trichloride.

Esters of alpha linolic acid tetrabromide were obtained by the interaction of the acid chloride and various alcohols.

The following esters were prepared: Methyl, ethyl, propyl, isopropyl, and allyl.

The melting points of these esters and their solubility in various solvents were determined.

NOTE ON FRAMBŒSIA IN SUMATRA[1]

By B. M. VAN DRIEL

Of the Hospital Soengei, Sengkol, Medan, Sumatra

HOSPITAL SOENGEI, SENGKOL,
Medan, Sumatra, 8 April, 1927.

Dear Dr. LOPEZ-RIZAL: In the Philippine Journal of Science for August, 1926, I read the interesting papers on Frambœsia.

On page 498 I see the statement of Winckel quoted, who stated in his article on Yaws in the Meded. v. d. Borgerl. Geneesk. Dienst in Ned. Indië 1923, 213, that "in Sumatra many cases are found at a height of 3,000 feet."

Winckel says these cases do occur on the plateaus in the Batak lands. He himself has never resided there but has the statement only from other medical officers, who told him that in the Batak countries, especially among the tribe of the Karo Bataks, yaws was very frequent; but, on account of not being personally acquainted with the geographic situation, he did not know that a great many of the Karo Bataks are not living on the plateau but in the countries on the slopes of the mountains, which are much lower, some of the Batak kampongs being situated at not more than 60 or 100 meters above sea level.

From personal experience (I lived for nearly three years on the Batak plateau) I can assure you that there frambœsia is quite as rare as it is in Java at this altitude. I saw only some ten or twenty cases, most of them of a somewhat different type from that seen in the lowlands and rather a large percentage with tertiary lesions. I was on the Batak plateau from 1920 until 1923. Some years earlier the well-known Professor Schuffner also made a survey of the plateau and, according to many personal oral communications to me, he also thought frambœsia to be extremely rare there.

[1] In August, 1926, there appeared in the Philippine Journal of Science an article by Dr. L. Lopez-Rizal and Dr. A. W. Sellards on frambœsia, in which they quoted a statement by Winckel. In April, 1927, Dr. Lopez-Rizal received a letter from Dr. B. M. Van Driel in regard to this quotation. Doctor Van Driel expressed the desire that this letter be published. The letter, which is self-explanatory, is here reproduced, with some slight editorial corrections.—EDITOR.

Some time ago I met Doctor Winckel in Java and told him what I thought about his statement. He agreed with me that he had no personal acquaintance with the question and had understood from his conversation with Doctor Schuffner what he communicated to the papers. It was, however, too late to revoke the statement as it had already appeared in the Trop. Dis. Bull. and so in the international literature.

In a paper on account of the sixtieth anniversary of Professor Schuffner which appeared in our journal I had the occasion to try to eradicate Doctor Winckel's statement which really is wrong.

I am, sir,

Yours faithfully,
B. M. VAN DRIEL.

FIFTH REPORT UPON DIPTERA PUPIPARA FROM THE PHILIPPINE ISLANDS

By G. F. FERRIS

Of Stanford University, California

NINETEEN TEXT FIGURES

The material upon which this, the fifth, report upon the Diptera pupipara of the Philippine Islands is based has been received at various times from Mr. R. C. McGregor. In addition Mr. P. A. Buxton has permitted me to include certain species collected by him in the New Hebrides, all of which have some bearing upon the Philippine material. Altogether, fourteen species are here dealt with, all in the family Hippoboscidæ; five of these are described as new.

Genus ORNITHOICA Rondani

In the fourth paper of this series I dealt with this genus and recorded a single species from the Philippine Islands. It is now possible to add three more species to the list as well as further records of the first species.

ORNITHOICA PROMISCUA Ferris and Cole.

Ornithoica promiscua Ferris and Cole, FERRIS, Philip. Journ. Sci. 28 (1925) 331, figs. 1 and 2.

Present records.—From *Leucotreron leclancheri* Bonaparte, *Centropus sinensis* (Stephens), and *Pitta atricapilla* Lesson, Puerto Princesa, Palawan; and from *Batrachostomus microrhynchus* Grant, Limay, Bataan Province, Luzon, all collected by R. C. McGregor; from *Ceyx melanura* Kaup, Alabat Island, Tayabas Province (*F. Rivera*).

ORNITHOICA PUSILLA (Schiner). Fig. 1.

Ornithomyia pusilla SCHINER, Reise Novara 374 (1868).

Ornithoica pusilla (Schiner), SPEISER, Ann. Mus. Civico (2a) 20 (1901) 559.

Ornithoica pusilla (Schiner), SPEISER, Zeitsch. f. Hym. u. Dipt. 4 (1904) 86.

Ornithoica confluenta (Say), ALDRICH, Ins. Inscit. Menstruus 11 (1923) 79 (part).

Previous records.—Recorded by Schiner from *Halcyon veneratum* in Tahiti. Speiser (1904) records under this name

specimens from *Pitta vigorsi* from Christmas Island. Aldrich records specimens (as *O. confluenta*) from *Halcyon* sp., Philippine Islands, which on the basis of hosts might well be this species.

In another paper, now in press, I am recording the species from the New Hebrides and Samoa from *Halcyon juliae* and *Aplonis atrifusca*.

Present record.—A male from Puerto Princesa, Palawan, September 6, 1926 (*McGregor*), host recorded as in doubt, being either *Spilopelia* sp., *Caprimulgus* sp., or *Syrnium* sp.; and a male from *Astur* sp., San Andales, Rizal Province, Luzon (*Rivera*).

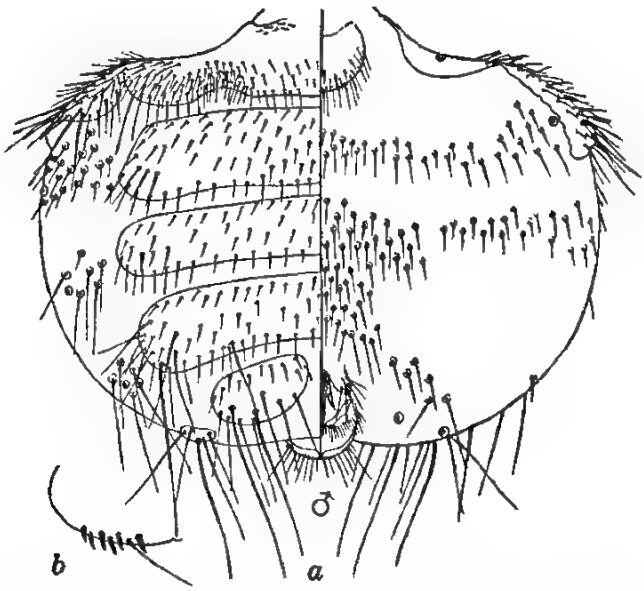


FIG. 1. *Ornithoica pusilla* (Schiner); *a*, abdomen of male; *b*, posterior margin of posterior trochanter.

Notes.—Two specimens from the Philippines agree exactly with the specimens from the New Hebrides and Samoa. I have identified the latter as *O. pusilla* solely upon the basis of the community of hosts of the genus *Halcyon* and the correspondence in general locality. It must be emphasized that this identification is merely a guess, the demonstrated fact that two perfectly distinct species of this genus may occur upon the same host species in the same locality reducing the value of determinations made upon these bases practically to zero. There is nothing in the existing literature which would make a more positive determination possible.

The species is almost identical in size and characters of the head, thorax, and wings with *O. promiscua;* so much so that for these parts of the body the figures previously given for the latter species will serve equally well for *O. pusilla.* The two species differ, however, very markedly in other respects.

The trochanters of the posterior legs in *O. pusilla* (fig. 1, *b*) bear upon their posterior margin a series of short, stout, black setæ which are not present in *O. promiscua.* The abdomen (fig. 1, *a*) bears but three transverse tergal plates in addition to the usual basal plate and paired apical plates, while in *O. promiscua* there are four of these transverse plates. The ventral side of the abdomen lacks the very conspicuous chitinous tubercles which are conspicuous features of the latter species.

Ornithoica pusilla is very similar to a species which I have redescribed as *O. beccariina* Rondani, from Borneo, in a paper now in press in the Sarawak Museum Journal. The latter species, however, lacks the black setæ on the posterior trochanters.

ORNITHOICA UNICOLOR Speiser. Fig. 2.

Ornithoica unicolor SPEISER, Ann. Mus. Civico (2a) 20 (1901) 556.

Previous records.—Recorded only from Sumatra, without indication of host.

Present record.—A single mutilated specimen from *Penelopides manillæ* (Boddaert), Isabela Province, Luzon, February 15, 1926 (*G. Taguibao*).

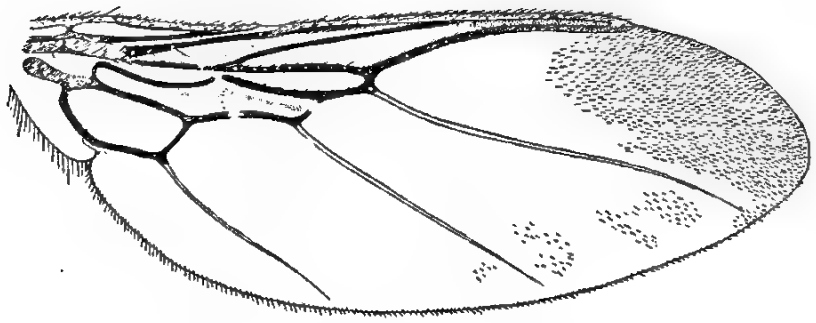


FIG. 2. *Ornithoica unicolor* Speiser; wing.

Notes.—The original description of *O. unicolor* is entirely worthless except that it notes the unusual size—for this genus—of the species. The length, based upon a dried specimen, is given as 3.5 millimeters, and the length of the wing as 4 millimeters. With these measurements the single specimen at hand

agrees closely and, as no other species of similar size is known, there is a reasonable chance that the identification is correct.

Unfortunately, the single specimen has the abdomen so badly mutilated that it cannot be definitely reconstructed and I am therefore leaving the description of the body for some future time, hoping to secure adequate material. The wings, however, are complete and I am here figuring them (fig. 2). It will be noted that they differ strikingly from the wings of *O. promiscua*—with which all the other available species agree very closely—in the distribution of the vestiture of minute setulæ. In *O. unicolor* these setulæ are confined to very small areas near the extreme apex of the wings. This alone is sufficient to mark the species.

ORNITHOICA PHILIPPINENSIS sp. nov. Fig. 3.

Specimens examined.—A single male from *Ceyx melanura* Kaup, Alabat Island, Tayabas Province, Philippine Islands (*Rivera*).

Male.—Length on slide, 2.25 millimeters; length of wing, 2.5. In the characters of head, thorax, and wings apparently identical with the common type of the genus as previously figured and described in detail for *O. promiscua*, differing from this type in the following respects:

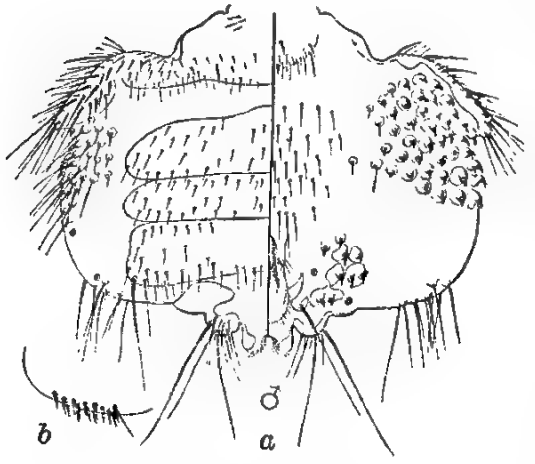


FIG. 3. *Ornithoica philippinensis* sp. nov.; *a*, abdomen of male; *b*, posterior margin of posterior trochanter.

Trochanters of posterior legs (fig. 3, *b*) with a series of short, stout, black setæ on the posterior border, as in *O. pusilla*. Posterior tibiæ apparently without a spur at the inner apex.

Abdomen (fig. 3, *a*) with the usual basal tergite and with two subapical plates and, in addition to these, but three transverse tergal plates, as in *O. pusilla* and *O. beccariina*. Ventral side with numerous, large and conspicuous, heavily chitinized tubercles, each bearing one or more short, stout setæ, the species differing in this respect from *O. pusilla* and *beccariina*.

Notes.—This species is evidently quite distinct from any of the other species that are available. If my identifications are correct, *O. turdi* (Latreille) and the evidently very similar *O. promiscua* Ferris and Cole, *O. pusilla* (Schiner), *O. unicolor* Speiser, and *O. beccariina* Rondani may be eliminated. There remain *O. confluenta* (Say) from North America, *O. exilis* (Walker) from New Guinea, *O. podicipis* von Röder from East Africa, *O. stipituri* (Schiner) from Australia, and *O. vicina* (Walker) from Jamaica to be considered. It is impossible to hazard even a guess as to which, if any, of these it might possibly be.

Genus ORNITHOMYIA Latreille

This genus, once inclusive of a large proportion of the Hippoboscidæ, is now restricted to a relatively small number of forms with the following assemblage of characters. Wings present, functional, noncaducous, having several veins in addition to the costa, these including three "cross veins" and consequently with an "anal cell," the "third vein" (R_{4+5}) not confluent with the costa. Ocelli present. Claws three-toothed. Antennæ elongate, slender, tapering toward the apex and more or less divergent. Abdomen without an area of minute, transverse striations on the dorsum.

Type of the genus, *Hippobosca avicularia* Linnæus.

This genus has in the past been regarded as a very large one but, with its comparatively recent dismemberment and the distribution of many of its species to the genera *Ornithoctona, Ornitheza,* and *Ornithopertha,* it retains but a small number of forms. There is evidently much confusion within the group and the status of the various forms still remaining within the genus is doubtful. In the Philippine material there is represented a single species which I am referring doubtfully to a named form.

I have elsewhere indicated that the absence of a ctenidium or the first segment of the posterior tarsi would aid in separating this genus from *Ornithoctona.* Material now available indicates that this character is not of generic significance.

ORNITHOMYIA AVICULARIA (Linnæus) ? **Figs. 4 and 5.**

Ornithomyia avicularia (Linnæus), MASSONAT, Ann. Univ. Lyon N. S. (1) 28 (1909) 271–278, pl. 4, figs. 33 and 34.

Ornithomyia avicularia (Linnæus), FERRIS and COLE, Parasitology 14:199, 200, figs. 15 and 16.

Previous records.—If the existing records are to be accepted as valid, this is a widely distributed species, occurring

on birds of many genera and species in Europe, North and South America, New Zealand, and Australia.

Present record.—A single female from *Anthus gustavi* Swinhoe, Puerto Princesa, Palawan, Philippine Islands, October 9, 1925 (*McGregor*).

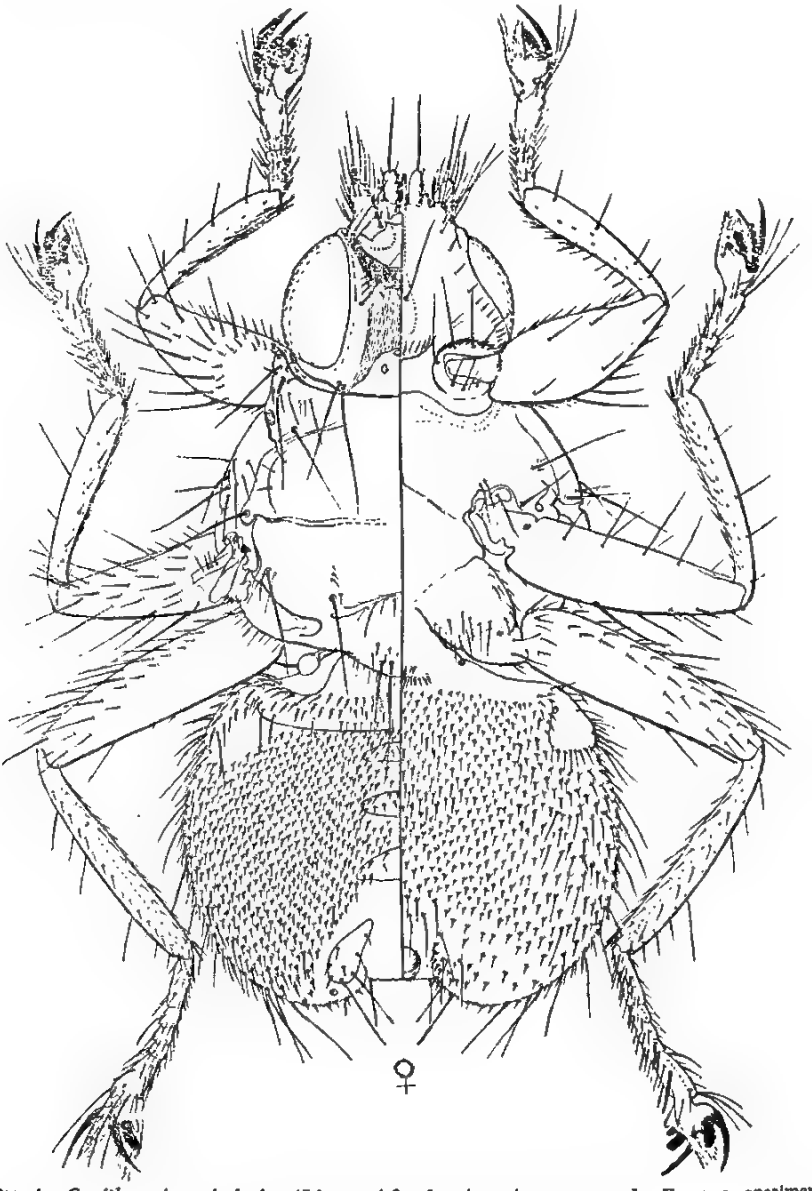


FIG. 4. *Ornithomyia avicularia* (Linnæus)?; female, wings removed. From a specimen from *Anthus gustavi* Swinhoe, Philippine Islands.

Notes.—I do not have available authentic European material representing this species, but the single Philippine specimen agrees exactly with specimens from western United States which I have considered to be *O. avicularia.* It also agrees with almost equal precision with specimens from the oystercatcher in England determined by Austen as *O. lagopodis* Sharp.

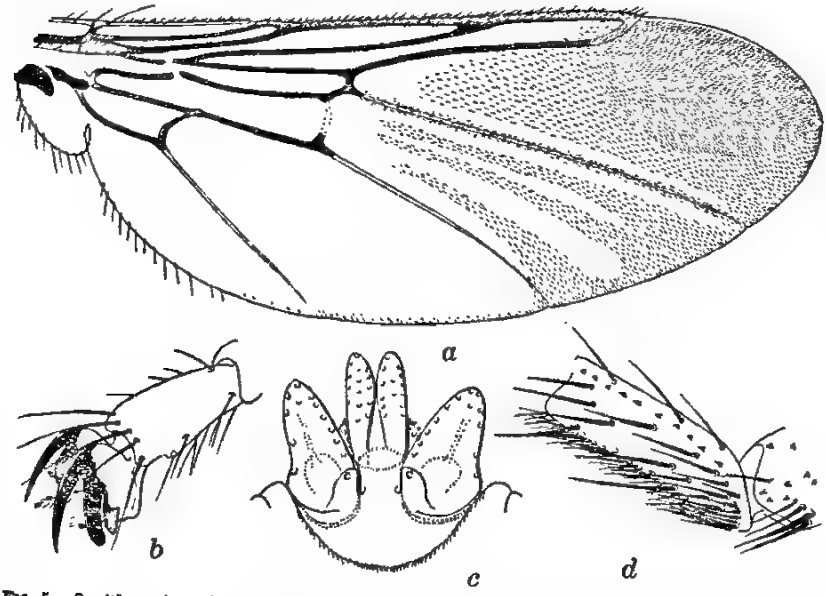


FIG. 5. *Ornithomyia avicularia* (Linnæus) ♀; *a*, wing; *b*, claws; *c*, clypeal region of head; *d*, first segment posterior tarsus. From the same specimen as fig. 4.

The accompanying figures should make the identification of the species simple and I add only the following notes. Length, on slide, 5 millimeters; of wing, 5. The wing (fig. 5, *a*) shows the setulæ arranged in a characteristic pattern, which is quite constant throughout all the specimens examined. The darker area near the apex of the wing is caused by the fact that here the setulæ are present on both surfaces, while elsewhere they are confined to one side.

Genus ORNITHEZA Speiser

This genus has been dealt with in an earlier paper of this series.

ORNITHEZA METALLICA (Schiner). Fig. 6.

Ornitheza metallica (Schiner), FERRIS, Philip. Journ. Sci. 27 (1925) 419, 420, figs. 4 and 5.

Present record.—A single male from *Merops americanus* P. L. S. Müller, Casiguran, Tayabas Province, Luzon, Philippine

Notes.—I do not have available authentic European material representing this species, but the single Philippine specimen agrees exactly with specimens from western United States which I have considered to be *O. avicularia.* It also agrees with almost equal precision with specimens from the oystercatcher in England determined by Austen as *O. lagopodis* Sharp.

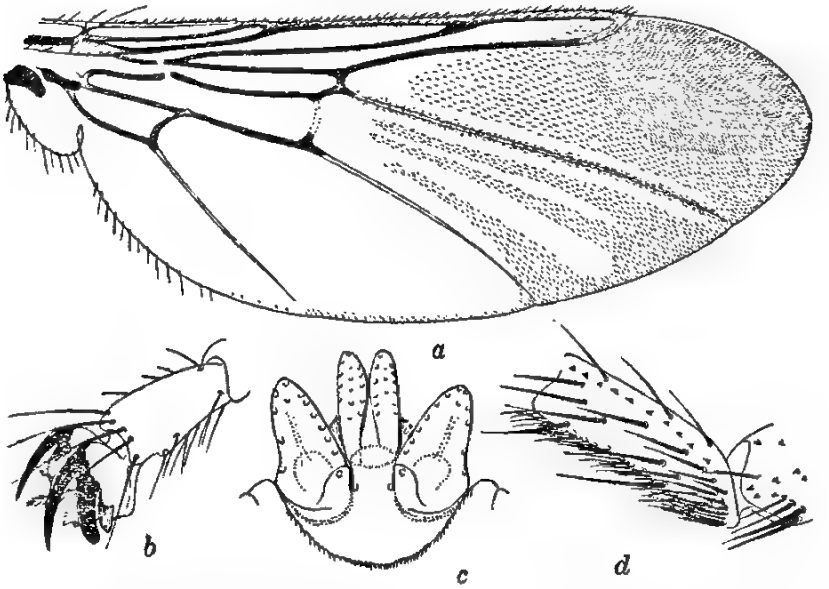


FIG. 5. *Ornithomyia avicularia* (Linnæus) ♀; *a*, wing; *b*, claws; *c*, clypeal region of head; *d*, first segment posterior tarsus. From the same specimen as fig. 4.

The accompanying figures should make the identification of the species simple and I add only the following notes. Length, on slide, 5 millimeters; of wing, 5. The wing (fig. 5, *a*) shows the setulæ arranged in a characteristic pattern, which is quite constant throughout all the specimens examined. The darker area near the apex of the wing is caused by the fact that here the setulæ are present on both surfaces, while elsewhere they are confined to one side.

Genus ORNITHEZA Speiser

This genus has been dealt with in an earlier paper of this series.

ORNITHEZA METALLICA (Schiner). Fig. 6.

Ornitheza metallica (Schiner), FERRIS, Philip. Journ. Sci. 27 (1925) 419, 420, figs. 4 and 5.

Present record.—A single male from *Merops americanus* P. L. S. Müller, Casiguran, Tayabas Province, Luzon, Philippine

Islands (*Rivera*). In another paper, now in press elsewhere, I am recording the species from *Aplonis brevirostris* in Samoa and *Halcyon juliae* in the New Hebrides.

Notes.—In my earlier notes on this species the female alone was available. The male resembles the female very closely in all the characters of head, thorax, and wings, but differs markedly in the abdomen.

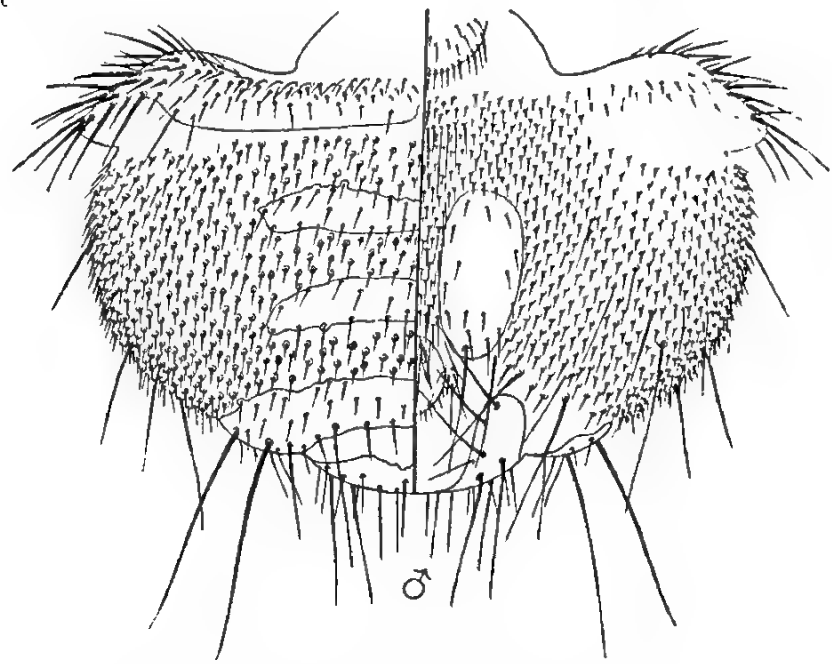


FIG. 6. *Ornitheza metallica* (Schiner); abdomen of male.

The abdomen (fig. 6) bears, in addition to the basal tergite, two rather large plates which extend across the mesal third of its width, these followed by a third plate which extends entirely across the abdomen, and also by an apical plate which extends to the ventral aspect. On the ventral side, just anterior to the genital opening, are a pair of oval plates, one on each side of the median line. Except for the plates, the entire abdomen is membranous and is thickly beset with short setæ, which are borne upon small prominences. The apical and preapical plates bear several long setæ as indicated in the figure.

The single Philippine specimen differs slightly from the one male available from Samoa, having the tergal plates somewhat narrower; but the females agree entirely and there seems no reason to believe that more than one species is involved.

Genus ORNITHOCTONA Speiser

In an earlier paper of this series, I discussed this genus and recorded one species from the Philippine Islands. This species appears again in the material at hand.

ORNITHOCTONA NIGRICANS (Leach). Figs. 7 and 8.

Ornithomyia nigricans LEACH, Mem. Wernerian Nat. Hist. Soc. 2 (1818) 558, figs. 7 to 10.

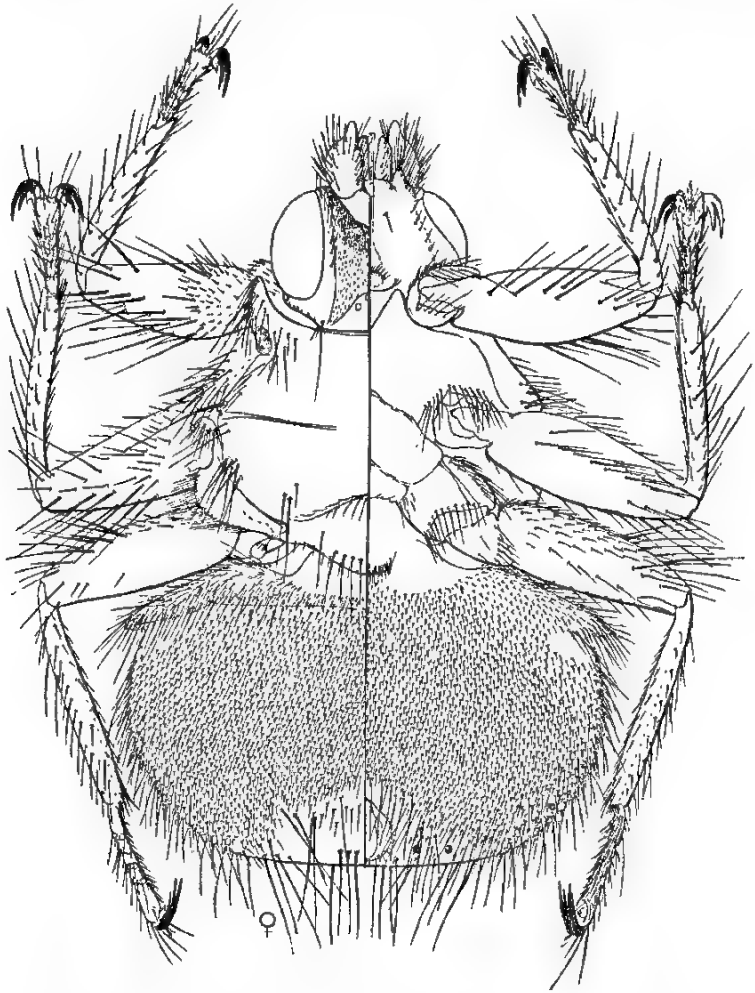


FIG. 7. *Ornithoctona nigricans* (Leach); females, wings removed. From a Philippine specimen.

Ornithomyia (*Ornithoctona*) *nigricans* (Leach), AUSTEN, Ann. & Mag. Nat. Hist. VII 12 (1903) 263.

Ornithoctona nigricans (Leach), SPEISER, Ann. Mus. Civico Genova (3) 1 (1905) 338 to 343.

Ornithoctona magna FERRIS, Philip. Journ. Sci. 28 (1925) 339 (without description).

Ornithoctona magna FERRIS, Sarawak Mus. Journ. (in press).

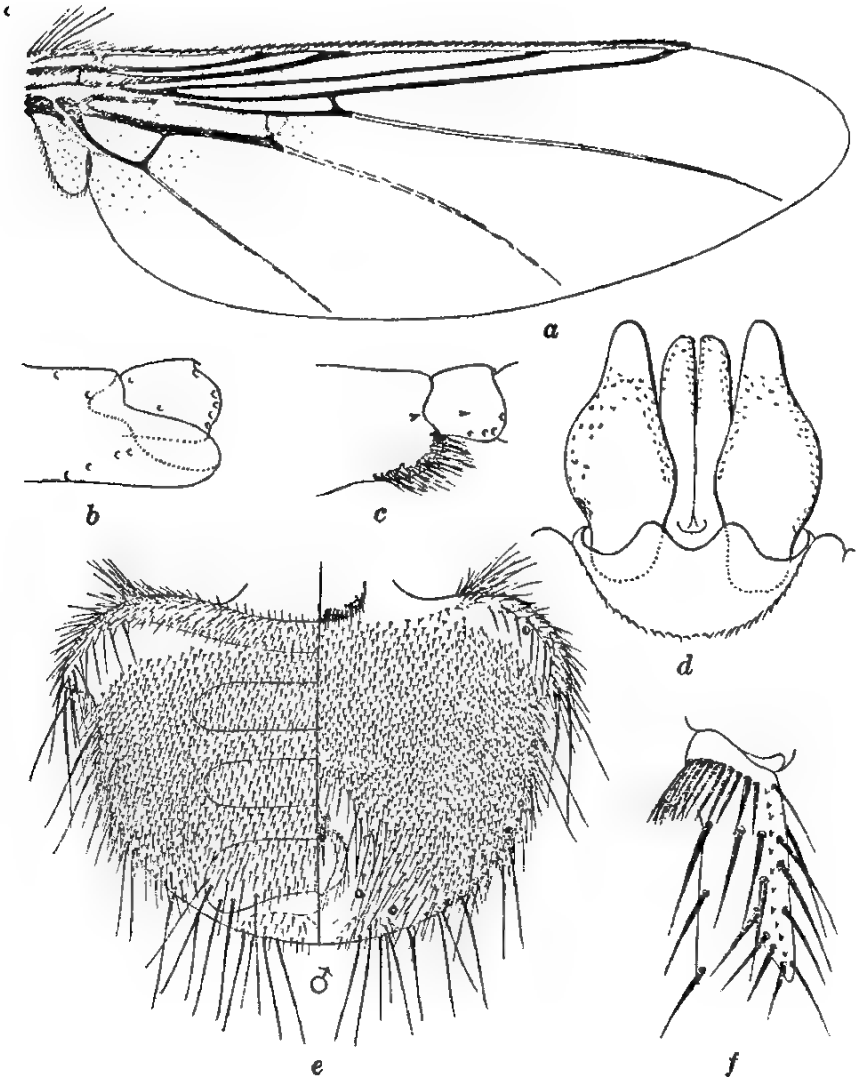


FIG. 8. *Ornithoctona nigricans* (Leach); *a*, wing; *b*, apex of anterior tibia of female; *c*, apex of anterior tibia of male; *d*, clypeal region; *e*, abdomen of male; *f*, first segment of posterior tarsus.

Previous records.—A widely distributed species on many hosts in the Oriental and southern Pacific regions. Recorded from the Philippine Islands by Speiser, and by Ferris as *O. magna*.

Present records.—From *Circus wolfi*, Tanna, New Hebrides (*P. A. Buxton*) and from the Philippine Islands as follows: *Haliastur intermedius* Gurney, Manila (*McGregor*); *Calisitta œnochlamys* (Sharpe) and *Oriolus albiloris* Grant, San Mariano, Isabela Province, Luzon (*Tagaibao*); *Chalcophaps indica* (Linnæus), Limay, Bataan Province, Luzon (*McGregor*); *Muscadivores palawanensis* (Blasius), *Astur* sp., *Thriponax hargitti* Sharpe, *Corvus pusillus* Tweeddale, *Spilopelia tigrina* (Temminck and Knip), and *Dendrophassa vernans* (Linnæus), all from Puerto Princesa, Palawan (*McGregor*); *Phapitreron amethystina* Bonaparte and *Lichtensteinipicus funebris* (Valenciennes), Lucban, Tayabas Province, Luzon (*Rivera*); *Artamides striatus* (Boddaert), Burgos, Ilocos Sur Province, Luzon (*Rivera*); *Artamus leucorynchus* (Linnæus) and *Leucotreron leclancheri* Bonaparte, Casiguran, Tayabas Province, Luzon (*Rivera*); *Dryococcyx harringtoni* Sharpe, Palawan (*McGregor*); *Penelopides manillae* (Boddaert), San Andales, Rizal Province, Luzon (*Rivera*).

The description of this species as *Ornithoctona magna* has been in press nearly two years in the Sarawak Museum Journal. On the basis of material from Samoa and the New Hebrides identified by Mr. G. E. Bryant, probably by comparison with the types in the British Museum, I am placing *O. magna* as a synonym of *O. nigricans* (Leach). Speiser (cited above) has indicated a long series of names as probably being synonyms of this species and has recorded the species from the Philippine Islands.

This is an extremely large species, the female measuring as much as 12 millimeters on the slide, with a wing length of 10.5 to 11 millimeters. The male is smaller, attaining only 8 to 9 millimeters, with the same length of wing. The females vary noticeably in size, but the wing length remains very constant.

In pinned specimens the species appears practically black, but in alcoholic material it is of a general gray-brown color.

The female (fig. 7) differs from other species of the genus that are available in the complete absence of tergal plates on the abdomen and in having the apex of the anterior tibiæ (fig. 8,

b) produced on the inner side into a lamellate process that almost incloses the first tarsal segment.

The male differs from the female chiefly in having three large tergal, abdominal plates (fig. 8, *e*) and in lacking the lamellate process on the anterior tibiæ, this being replaced by a tuft of small setæ (fig. 8, *c*).

The wing (fig. 8, *a*) is entirely devoid of setulæ.

Genus MYIOPHTHIRIA Rondani

Myiophthiria FERRIS, Philip. Journ. Sci. 28 (1925) 336.
Myiophthiria AUSTEN, Parasitology 18 (1926) 359.

I discussed this genus in an earlier paper of this series. A further discussion will be found in the paper of Austen, cited above. In all, three species have been recorded in the genus, but of these one, *M. capsoides* Rondani, has been placed by Speiser as a synonym of *M. reduvioides* Rondani. The former was originally described from the Philippine Islands. On the basis of the notes given by Austen it would appear that certain specimens which are at hand from the New Hebrides definitely represent *M. reduvioides* and, if Philippine material should be regarded as belonging to a distinct species, they may be regarded as *M. capsoides*. There are slight differences between the New Hebridean and the Philippine material, as indicated below, but I am not disposed to consider that more than one species is involved.

To my earlier notes there should be added the statement that the posterior tarsi bear at the base of the first segment a transverse comb of setæ, similar in all respects to that which is found in the genus *Ornithoctona* and sometimes in *Ornithomyia*.

MYIOPHTHIRIA REDUVIOIDES Rondani. Fig. 9.

Myiophthiria reduvioides Rondani, FERRIS, Philip. Journ. Sci. 28 (1925) 337, 338, fig. 5.

Present record.—Two males and two females from *Collocalia francica vanicorensis*, Hog Harbor, New Hebrides (*Buxton*).

Notes.—In my earlier discussion of this species the female alone could be redescribed. The material now available contains both males and females. The females from the New Hebrides differ from the single female from the Philippine Islands only in the character of the tergal plates of the abdomen. In the former there are two median plates in addition to the paired apical plates, while in the latter there is but one median plate; furthermore, all the plates are larger in the

New Hebridean specimens. The difference, however, is not very great and I am not inclined to regard it as especially significant.

The male differs from the female, as previously described and figured by me, only in the characters of the abdomen (fig. 9). There are three transverse tergal plates, in addition to the apical pair, the third of these reaching almost entirely across the abdomen. The external genitalia are very inconspicuous, the claspers being extremely minute.

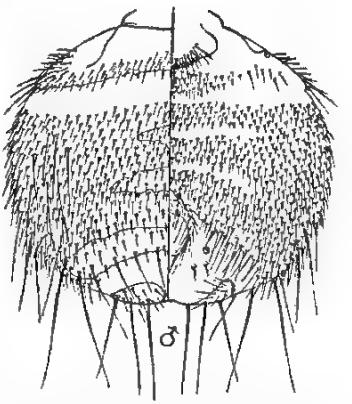


FIG. 9. *Myiophthiria reduvioides* Rondani; abdomen of male. From a specimen from the New Hebrides.

Genus **PSEUDOLYNCHIA** Bequaert

Lynchia Weyenberg, FERRIS, Philip. Journ. Sci. 27 (1925) 415.
Pseudolynchia BEQUAERT, Psyche 32 (1926).

Bequaert has critically examined the description of *Lynchia penelopes* Weyenbergh, which is the type of the genus, and has concluded that it does not belong with the species with which it has commonly been associated but with the group for which the name *Ornithoponus* is now employed. For the species thus left without a generic name he has proposed the name *Pseudolynchia*, with the former *Lynchia maura* (Bigot) as type.

PSEUDOLYNCHIA MAURA (Bigot).

Lynchia maura (Bigot), FERRIS, Philip. Journ. Sci. 27 (1925) 416, 417, figs. 2 and 3.

Present record.—A single female from *Spilopelia tigrina* (Temminck and Knip), Puerto Princesa, Palawan, Philippine Islands (*McGregor*).

Notes.—My previous record of this species from the Philippine Islands was based upon the comparison of a single male with a female from Europe. The female from the Philippines which is now at hand confirms the identification, agreeing very closely with the European specimen.

The species has previously been recorded only from pigeons, and it may be noted that the present host record has to do with a bird of the same family.

Genus OLFERSIA Wiedemann

Pseudolfersia of authors.

This genus, which is probably to be regarded as sufficiently distinct from *Lynchia* (*Olfersia* of authors, *Ornithoponus*, *Icosta*), is definable by the following group of characters. Wings present, functional, noncaducous, with several veins behind the costa, with two "cross veins," rm and m_3, present and consequently with an "anal cell;" abdomen with a median dorsal area of transverse striations; claws three-toothed; ocelli absent; clypeus elongate, being nearly one-half the length of the head and deeply cleft by a narrow median incision; pleurotergite of the mesothorax with a nipplelike protuberance.

The type of the genus is *Feronia spinifera* Leach.

The nomenclatorial permutations through which the name *Olfersia* has come to be applied to this group rather than to the much larger group of species with which it was formerly associated have been sufficiently explained by Aldrich.

OLFERSIA SPINIFERA (Leach). Figs. 10 and 11.

Pseudolfersia spinifera (Leach), FERRIS and COLE, Parasitology 14 (1922) 196 to 198, figs. 13 and 14.

Olfersia spinifera (Leach), ALDRICH, Ins. Inscit. Menstruus 11 (1923) 78.

Previous records.—This species has many times been recorded from various parts of the Tropics as a parasite of the frigate bird *Fregata aquila* (Linnæus). Ferris and Cole have considered that *Olfersia diomedeae* (Coquillet) from *Diomedea irrorata* on the Galapagos Islands, and *O. vulturis* Van der Wulp, from vultures in Central and South America, are synonyms.

Present records.—Males and females from *Fregata aquila* (Linnæus), Cavili Island, Philippine Islands (*W. Schultze*) and a single female from Laysan Island from "wedge-tailed shearwater."

Notes.—The species is very well known and needs no extended description here. The accompanying figures should make its identification simple. However, the forms associated with this species present something of a problem. I have, in company with F. R. Cole, considered that *O. diomedeae* (Coquillet) and *O. vulturis* Van der Wulp are synonyms of *O. spinifera*, but a review of the material upon which my conclusions were based and a study of further material raises some doubt as to the correctness of this view.

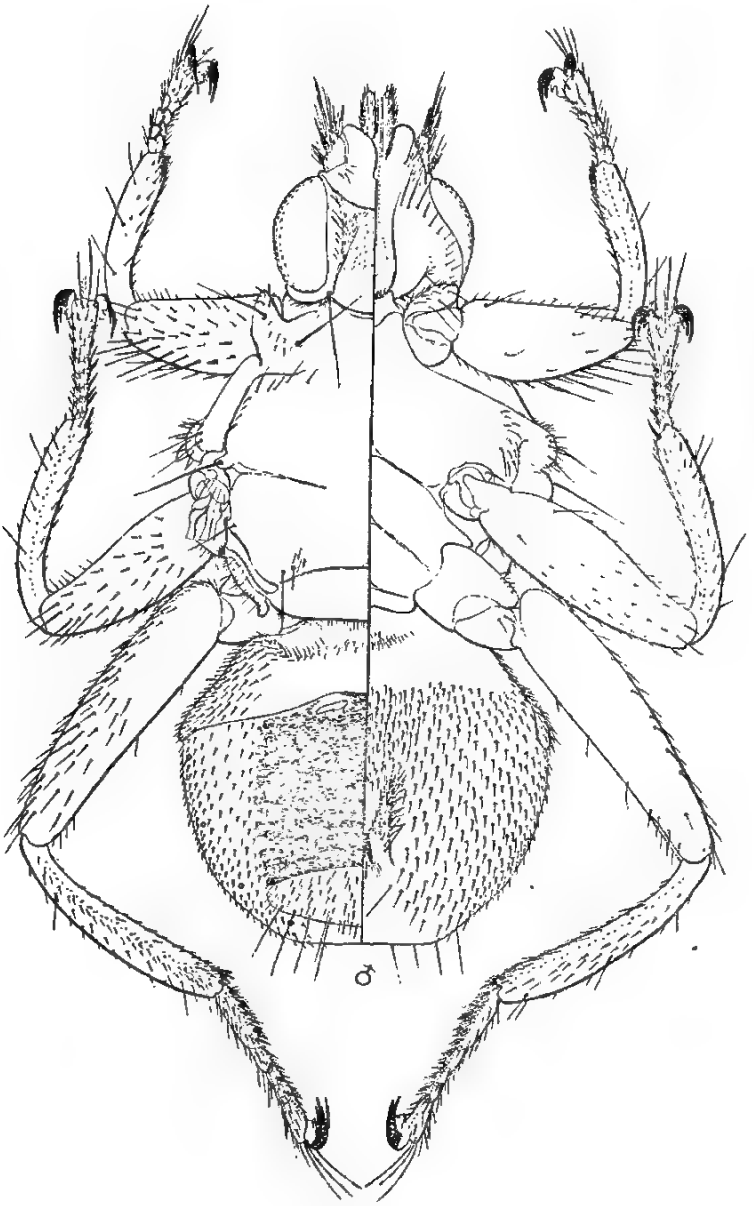


FIG. 10. *Olfersia spinifera* (Leach); male, wings removed. From a Philippine specimen from *Fregata aquila* (Linnæus).

All of these forms are very similar, indeed, as far as their general characters are concerned. There is evidently some variation in individuals which may reasonably be regarded as belonging to the same species, for specimens from the frigate bird at Cape San Lucas, Lower California, differ from the Philippine specimens in having the posterior margin of the head much more deeply lobed, and the vertex more produced posteriorly. Also, they differ in having a small but distinct patch of setulæ on the anal area of the wing, which is entirely bare in the Philippine specimens.

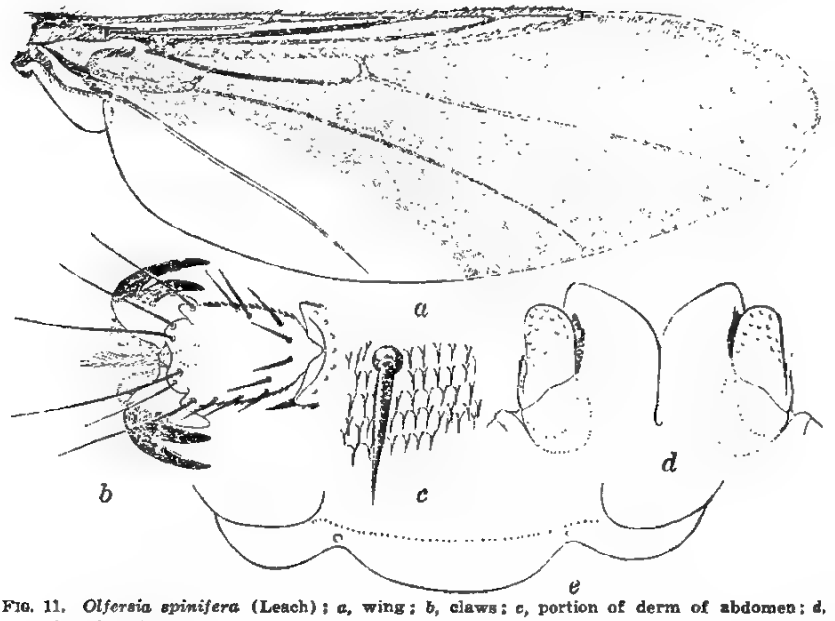


FIG. 11. *Olfersia spinifera* (Leach); *a*, wing; *b*, claws; *c*, portion of derm of abdomen; *d*, clypeal region; *e*, posterior margin of head. From the same specimen as fig. 10.

A paratype specimen of *O. diomedeae* agrees with the specimen from the shearwater on Laysan Island in having part of the anal area, which is bare in the Philippine specimens, covered with setulæ on one side of the wing only, the remainder of the wing bearing setulæ on both sides.

Specimens from vultures in Central and South America agree in having the posterior margin of the head slightly less deeply lobed than do the Philippine specimens and in having the nipple-like prominence of the pleurotergite noticeably longer. They agree with the Philippine specimens in the characters of the wings.

It appears, then, either that there is a single variable species or that possibly several closely related forms are involved. The examination of a long series of specimens from various hosts and localities may serve to clear up the problem.

Genus LYNCHIA Weyenbergh

Lynchia WEYENBERGH, Anal. Soc. Cientif. Argent. 11 (1881).
Icosta SPEISER, Zeitsch. f. syst. Hymenopterologie und Dipterologie 5 (1905) 358.
Ornithoponus ALDRICH, Ins. Inscit. Menstruus 11 (1923) 78.
Ornithoponus FERRIS, Philip. Journ. Sci. 28 (1925) 332.
Lynchia BEQUAERT, Psyche 32 (1925).
Olfersia of most authors.

Bequaert has recently examined the status of certain species and has arrived at the conclusion that *Lynchia penelopes* Weyenbergh, which is the type of its genus, is congeneric not with the forms with which it has usually been associated but with those which have usually been included under the genus *Olfersia;* in other words, with that genus of which *Feronia americana* Leach is commonly accepted as the type. Aldrich has previously called attention to the nomenclatorial accident which makes necessary the transfer of the generic name *Olfersia* to the genus that has commonly been called *Pseudolfersia,* this transfer apparently leaving the group of *americana* without a name. For this group he proposed the new name *Ornithoponus,* with *americana* as the type.

Accepting Bequaert's view as to the generic position of *Lynchia penelopes* it becomes evident that the name *Ornithoponus* is a synonym of *Lynchia.* The name could not have stood, anyway, for it seems evident that it was antedated also by *Icosta* Speiser. In an earlier paper of this series, I called attention to a suspicion that these two genera cannot be separated unless some characters other than those given by Speiser for *Icosta* can be found. The material now available changes this suspicion to a definite conviction that *Icosta* must also be placed as a synonym of *Lynchia.*

The genus *Icosta* of Speiser was based solely upon the character of the clypeus, which is described as deeply emarginate, its arms projecting like horns about the base of the antennæ. Certain specimens here to be dealt with show this character very strongly developed, but the examination of a series of specimens shows the impracticality of attempting to separate these species generically from *Lynchia,* at least as represented by *americana.* There is, in fact, no essential difference.

I have previously called attention to my belief that most of the named species of this genus are unrecognizable on the basis of the descriptions. The accompanying figures, representing four species, will show how close is the similarity of general form and the nature of the characters which must be known and utilized for any definite specific separation. With the exception of a few forms, such as *L. sarta* (Ferris), which I have described in an earlier paper of this series, there is a very close adherence to a fixed general type. I am convinced that attempts to separate species on the basis of the usual pinned material can lead to nothing but confusion. It is not at all improbable that of the four species here described as new at least some are named forms.

LYNCHIA TUBERCULATA sp. nov. Figs. 12 and 13.

Specimens examined.—A single male from *Corvus pusillus* Tweeddale, Puerto Princesa, Palawan, Philippine Islands, August 9, 1925 (*McGregor*).

Male (*fig. 12*).—Length on slide, 4.5 millimeters; length of wing, 4.5.

Head with the clypeus (fig. 13, *b*) produced on each side into a tapering, hornlike process which much exceeds the antenna; vertical triangle (fig. 13, *c*) with a slight emargination and incision in the anterior margin.

Thorax with the humeral angles (humeral callosities) prominent and rather slender. Legs with no specially distinctive characters. Wings (fig. 13, *a*) with the venational type common to the genus, their entire surface beset with minute setulæ, excepting only the area behind the anal vein, this vein itself, and vein $M_3 + Cu$.

Abdomen with a single small tergal plate immediately caudad of the basal tergite and with a complete apical tergite. Over the membranous portions of the abdomen are numerous small, slender setæ, those in the lateral areas being borne upon pronounced chitinous tubercles.

Notes.—The combination of characters enumerated will distinguish this species definitely.

LYNCHIA SETOSA sp. nov. Figs 14 and 15.

Specimens examined.—One male, the holotype, from *Bubulcus coromandus* (Boddaert), Palawan (*McGregor*); and a single female, the allotype, from the same host species, Lucban, Tayabas Province, Philippine Islands (*McGregor*).

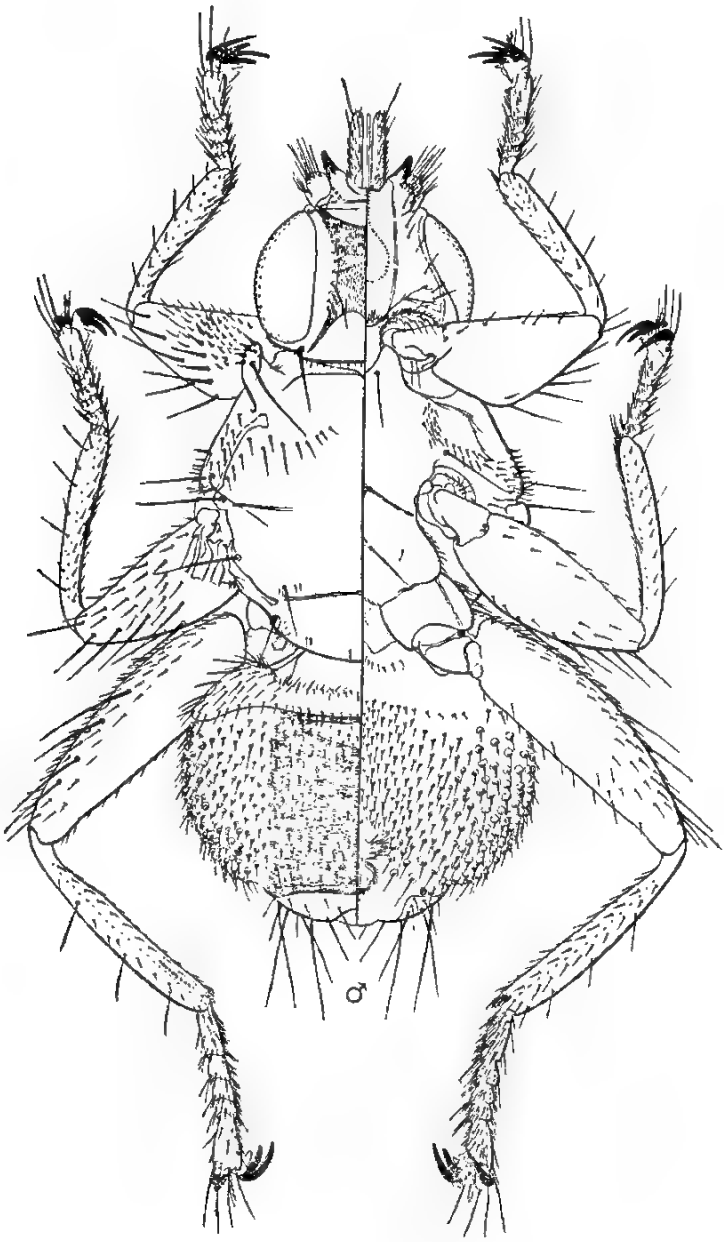


FIG. 12. *Lynchia tuberculata* sp. nov: male, wings removed.

Male (*fig. 14*).—Length on slide, 5.5 millimeters; length of wing, 5. A very dark species.

Head rather small and rather short and broad, the clypeus (fig. 15, *b*) deeply emarginate anteriorly, but the lateral arms only slightly exceeding the antennæ; vertical triangle (fig. 15, *c*) not emarginate or incised anteriorly; ventral side of the head with numerous setæ.

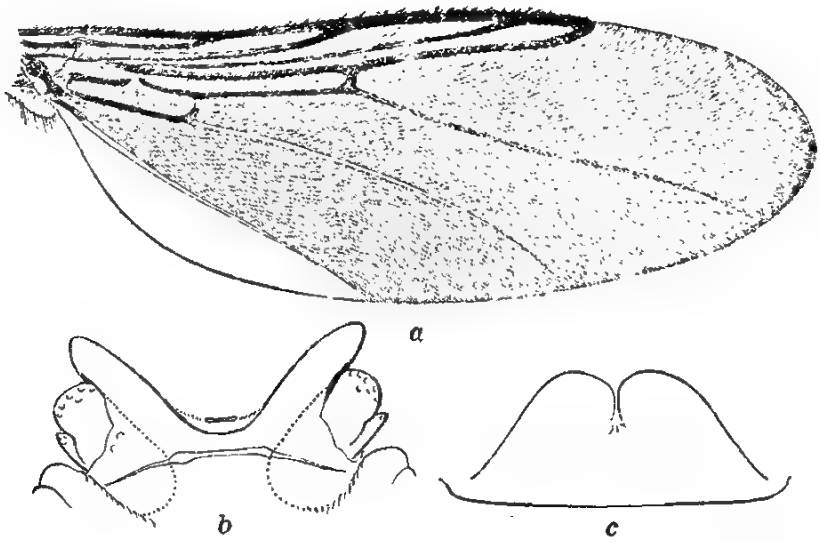


FIG. 13. *Lynchia tuberculata* sp. nov.; *a*, wing; *b*, clypeal region of head; *c*, vertical triangle.

Thorax noticeably broad and laterally angulate; humeral angles (humeral callosities) short and very broad. Legs with a notable paucity of large setæ and a notable abundance of extremely small setæ, the surfaces being almost entirely covered with the latter. Wings (fig. 15, *a*) with the venational type common to the genus but the subcosta not attaining the costa; entirely covered with setulæ, excepting only a portion of the area behind the anal vein, this vein itself, and vein $M_3 + Cu$.

Abdomen devoid of all but the usual basal and apical tergites; bearing numerous small setæ which are not borne on tubercles, or at the most with such tubercles extremely inconspicuous.

Female.—In all respects essentially identical with the male, the only dimorphism being in the position of the genital opening which is closer to the apex of the body, in the absence of the very minute claspers of the male, and the presence of a very small tergal plate just caudad of the basal tergite.

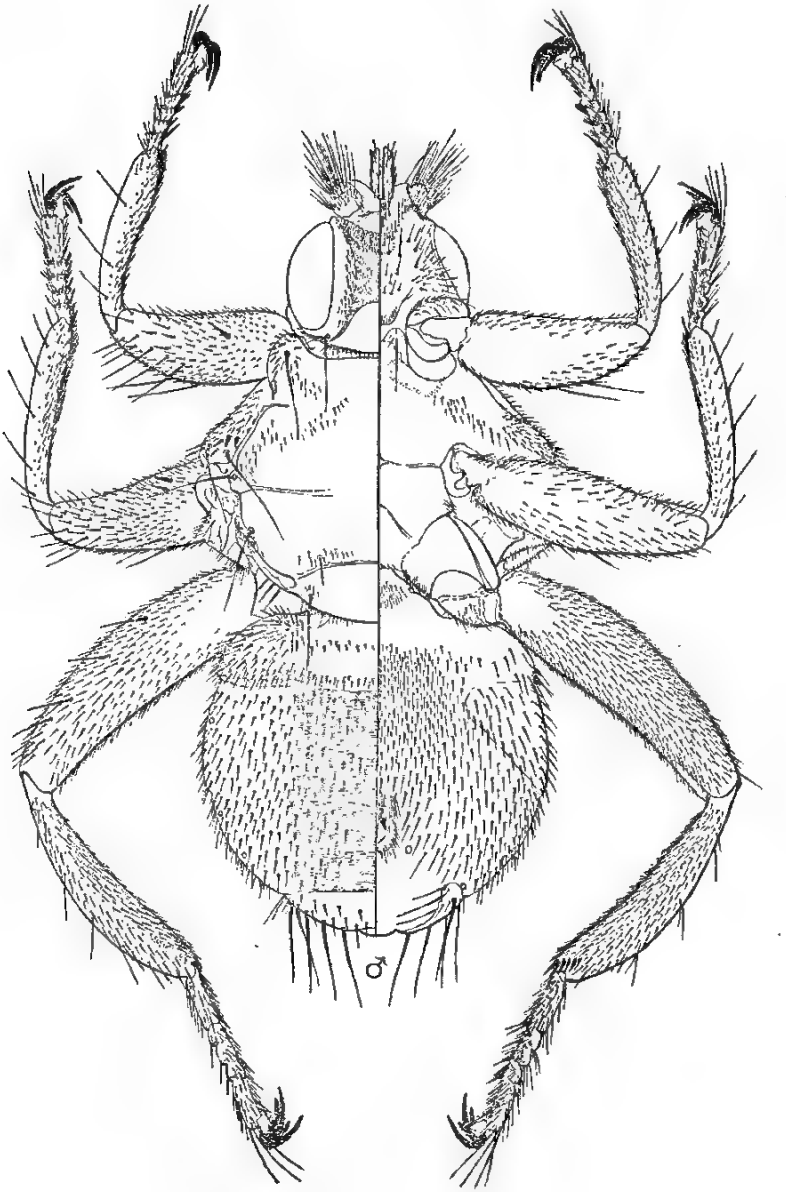


FIG. 14. *Lynchia setosa* sp. nov.; male, wings removed.

Notes.—I somewhat suspect this species of being *L. nigrita* (Speiser), although the only clues to the identity of the latter, which was described from Manila without any indication of host, are to be found in the note as to its dark color and the statement that the humeral callosities are "sehr auffallend stumpf, wenig spitzer als ein rechter Winkel * * *."

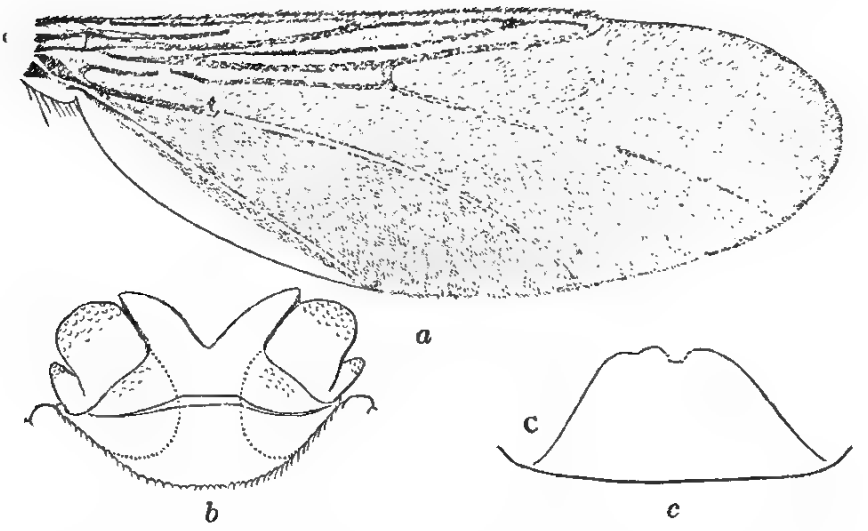


FIG. 15. *Lynchia setosa* sp. nov.: *a*, wing; *b*, clypeal region; *c*, vertical triangle.

LYNCHIA POLLICIPES sp. nov. Figs. 16 and 17.

Specimens examined.—Holotype, a male, one paratype male, and the allotype female from *Astur* sp., September 8, 1925, and a paratype female from *Prioniturus cyaneiceps* Sharpe, August 2, 1925, all from Puerto Princesa, Palawan, Philippine Islands (*McGregor*).

Male (*fig. 16*).—Length on slide, 5 millimeters; length of wing, 5.

Head with the clypeus (fig. 17, *b*) deeply emarginate and prolonged on each side into two very conspicuous, hornlike processes which greatly exceed the antennæ. Vertical triangle with a deep median incision in the anterior border.

Thorax with the humeral angles (humeral callosities) rather prominent and slender. Legs with no specially distinctive characters except that the fourth segment of the anterior tarsi (fig. 17, *c*) has the lobe on one side produced into a conspicuous thumblike process. Wings (fig. 17, *a*) with the venational type of the genus, but with the setulæ arranged in a characteristic fashion, the basal area and the anal area nearly to vein M_3+Cu

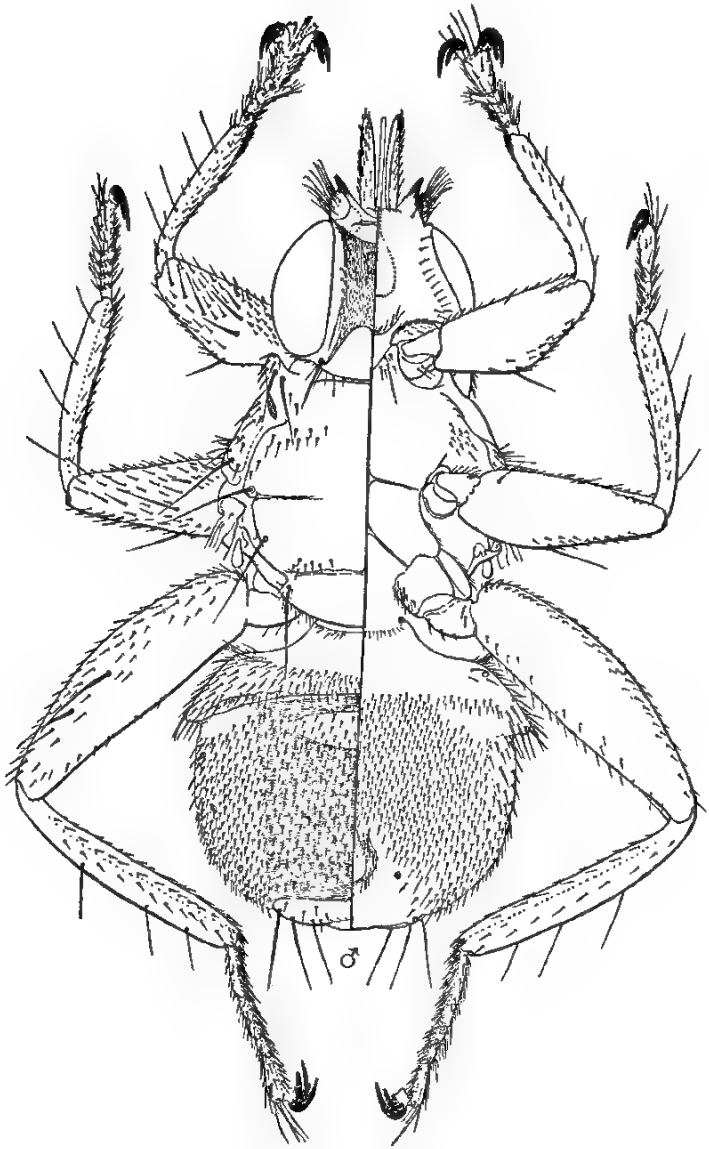


FIG. 16. *Lynchia pollicipes* sp. nov.; male, wings removed.

and a small area just distad of the crossvein formed by M_3 being bare.

Abdomen with the usual basal and apical tergites and with a moderately large tergal plate just caudad of the basal tergite; the membranous areas beset with numerous small, slender setæ, which are not borne upon tubercles, or with such tubercles at the most extremely small.

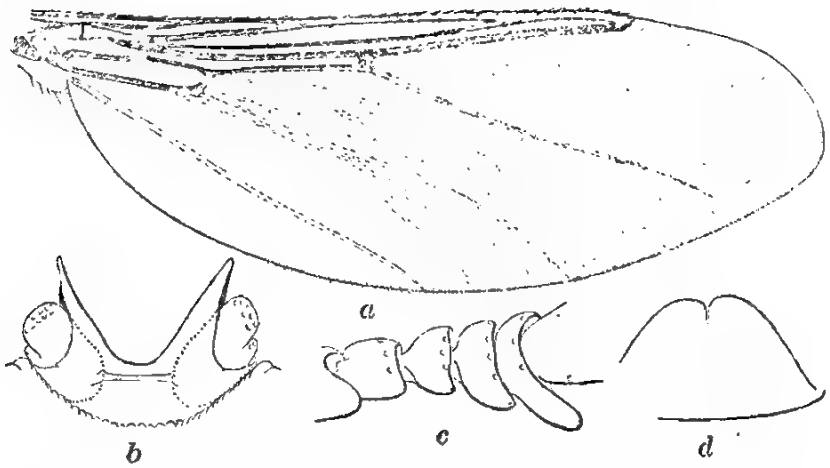


FIG. 17. *Lynchia pollicipes* sp. nov.; *a*, wing; *b*, clypeal region; *c*, portion of anterior tarsus; *d*, vertical triangle.

Female.—In general very similar to the male, differing, in addition to the essential sexual characters, in having the numerous setæ of the median ventral area of the abdomen larger, pale, and rather spikelike.

Notes.—The curious, thumblike lobe on the fourth joint of the anterior tarsi is alone a very distinctive character of this species.

LYNCHIA BICORNA sp. nov. Figs. 18 and 19.

Specimens examined.—A single male from *Penelopides manillæ* (Boddaert), Limay, Bataan Province, Luzon, November 21, 1924 (*McGregor*).

Male (*fig. 18*).—Length on slide, approximately 5.5 millimeters; length of wing, 5.5.

Head with the clypeus (fig. 19, *b*) deeply emarginate, the lateral arms prolonged into hornlike processes that far exceed the antennæ. Vertical triangle (fig. 19, *c*) with a deep median incision anteriorly.

Thorax with the humeral angles (humeral callosities) very prominent and slender. Sternum prolonged into a hooklike proc-

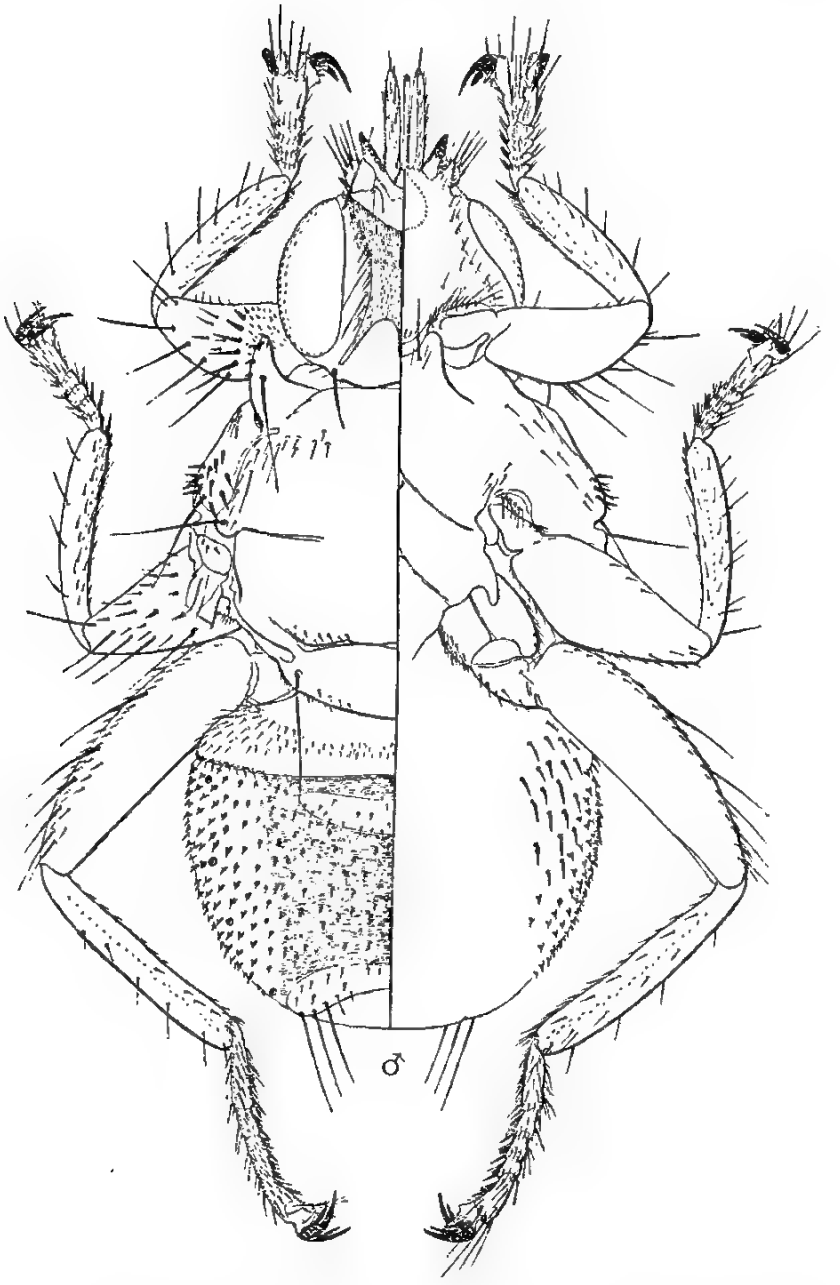


FIG. 18. *Lynchia bicorna* sp. nov.; male, wings removed. Abdomen incomplete because of mutilation of specimen.

ess that overlies the base of the posterior coxæ. Legs with no especially distinctive characters. Wings (fig. 19, *a*) with the venational pattern of the genus, but with nearly the posterior half devoid of setulæ.

Abdomen with the usual basal and apical plates and with a rather large tergal plate just caudad of the basal plate. Derm of the dorsum beset with rather numerous small setæ which are borne upon small tubercles.

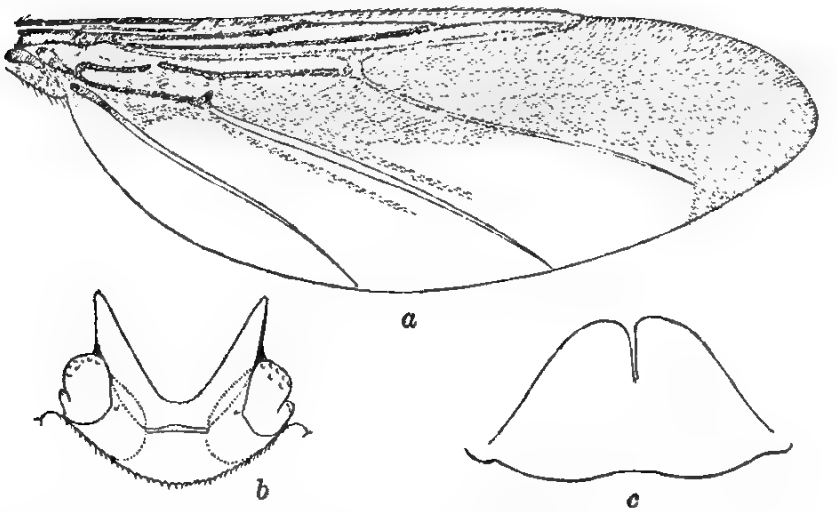


FIG. 19. *Lynchia bicorna* sp. nov.; *a*, wing; *b*, clypeal region; *c*, vertical triangle.

Notes.—The single specimen is mutilated to such an extent that it is not possible to reconstruct the ventral side of the abdomen, but it is evidently a distinct and entirely recognizable species, so I am nevertheless describing it.

There is a faint possibility that this may be *L. dioxyrhina* (Speiser), a species described from New Guinea from *Rhytidoceros plicatus* Forst. The basis for this possibility is to be found in Speiser's remarks, "Scheitel in der Mitte buchtig nach hinten vorgezogen, daneben eingezogen," a condition which is evident in the specimen at hand; and also the statement that upon the anterior femur "ist eine Reihe von mittellangen starren Borsten characteristisch, welche quer über die vordere Fläche des Schenkels verlaufend eine unbeborstete Würzelhälfte von einer unregelmässig beborsteten Endhälfte scheidet."

The latter condition is well fulfilled by this specimen, although the character is present in other species as well. Also, there is agreement in size. However, there may very well be several species to which all of these conditions will apply equally well.

ILLUSTRATIONS

TEXT FIGURES

HYNNIS MOMSA, A NEW PHILIPPINE PAMPANO

By ALBERT W. HERRE

Chief, Division of Fisheries, Bureau of Science, Manila

ONE PLATE

HYNNIS MOMSA Herre, sp. nov.

Dorsal I–20; anal I–16; about 10 scutes in lateral line, the last 5 much enlarged, very broad and high, but the last one much smaller than the 4 preceding.

The naked, angulate, elongate-rhomboid, roughly pentagonal body very deep and strongly compressed laterally, its greatest depth at origin of dorsal, 2.37 times in length; head higher than long, very narrow from side to side; its depth through center of eye 3.65, its length 3.92 times in total length; eye 4.77 times in head, 2.28 times in snout, which is 2.09 times in head; interorbital very high and narrow, its height 1.81 times eye, its thickness about 1.25 times eye; profile descends rapidly from origin of dorsal to the sharp angle just beyond eye, then at an angle of about 45° to mouth; ventral profile sharply angulate at origin of anal; mouth slightly oblique, maxillary 3.1 times in head, chin full, heavy, lower jaw slightly longer than upper; suborbital very deep, nearly equal to snout; dorsal low, first ray highest, a tenth higher than first anal ray, which is 1.86 times in head, dorsal and anal otherwise nearly identical; arch of lateral line high and very long, its diameter greater than length of straight part to fifth enlarged scute from end; depth of the elongate caudal peduncle less than its breadth, about 3.66 times in its length, 7.9 times in head; the very long, narrow, falcate pectoral reaches beyond a vertical from base of tenth dorsal ray, 2.86 + times in length; origin of the short ventral much in advance of pectoral and beneath opercle, its length 0.95 the height of first anal ray, and a little less than twice in that of head; caudal deeply and widely forked, about 3.84 times in length.

Color silvery, chin pearl white, with a black bar on upper posterior margin of opercle and a black spot in axil of pectoral; a short distance below dorsal a dark steel blue bar about 25

millimeters wide extends back to top of caudal peduncle and along it to caudal fin; on upper half of body, above pectoral and posteriorly, are dusky spots like thumb marks; the fins have no markings. Seen from above the fish is very dark steel blue, with a metallic luster.

Here described from the type, No. 15216 Bureau of Science collection. It is a ripe female, 730 millimeters long, or 920 millimeters including caudal fin, and was obtained in the Manila market April 12, 1927. A few specimens of this large fish are occasionally seen in the Manila market during the spring months. They come from near the entrance to Manila Bay or from Subic Bay, and are evidently an offshore fish, only caught at infrequent intervals in fish corrals.

Momsa, a Visayan name for carangoid fishes.

ILLUSTRATION

PLATE 1. *Hynnis momsa* sp. nov. Ripe female. (Drawing by Pablo Bravo.)

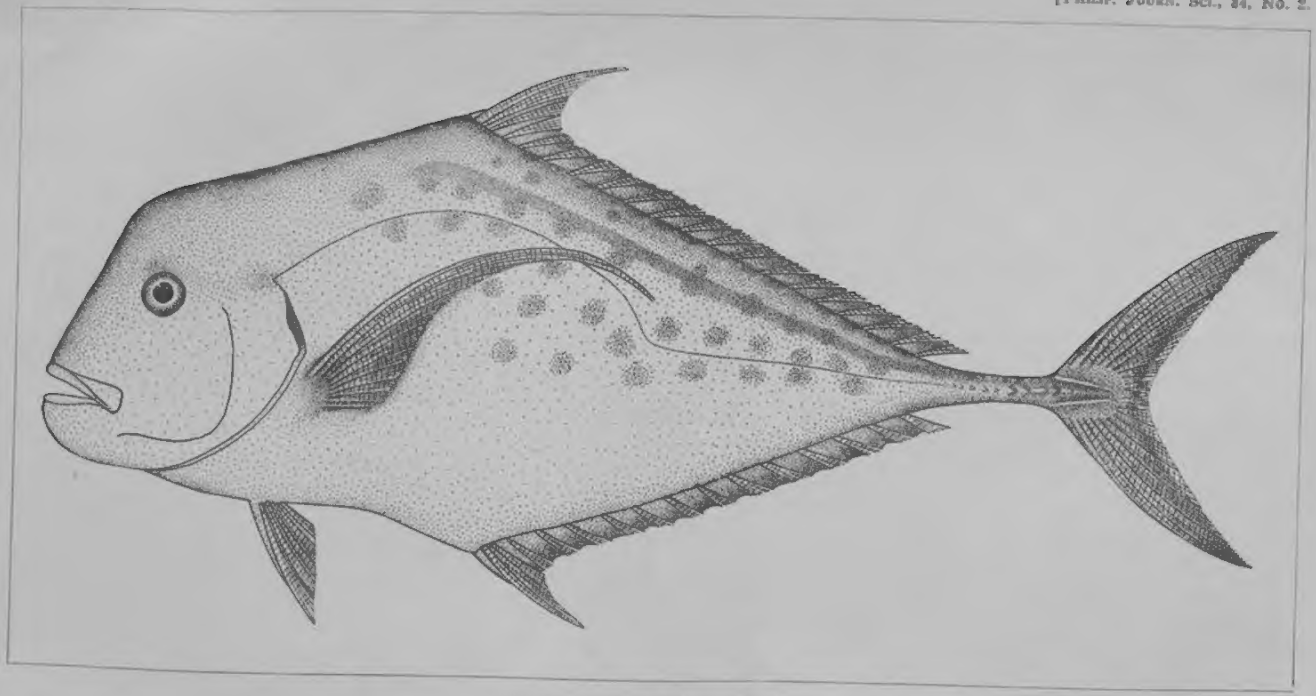


PLATE 1. HYNNIS MOMSA SP. NOV.